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DEVELOPMENT OF A MODEL (HAZPRED) FOR PREDICTING THE INCIDENCE OF HAZARDOUS CONTAMINANTS IN RAW SEWAGE - PHASE 1

TECHNICAL REPORT #5

A REPORT
OF THE

TORONTO AREA WATERSHED
MANAGEMENT STRATEGY
STEERING COMMITTEE

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Development of a model
(HAZPRED) for predicting the
incidence of hazardous
contaminants in raw sewage -

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- PHASE 1

TECHNICAL REPORT # 5

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TORONTO AREA WATERSHED
MANAGEMENT STRATEGY
STEERING COMMITTEE

Prepared by:
Canviro Consultants Limited
Kitchener, Ontario

December, 1984

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EXECUTIVE SUMMARY

Project Objectives

HAZPRED is an interactive microcomputer model designed to predict the nature, concentration and loading in sanitary wastewaters of selected hazardous contaminants (HCs) on the EPA's list of 129 priority pollutants. The following is a report detailing the development of the HAZPRED predictive methodology for dry weather sewage flows and giving the results of model validation based upon a field data collection program in two test catchments. Specific project objectives were as follows:

1. To develop a methodology that can be used to predict the incidence of the dominant EPA priority pollutants and their concentrations and loadings (to within an order magnitude in dry weather sewage flow), and to verify this predictive methodology by a well designed field sampling program in two selected catchments of diverse characteristics.
2. To characterize the nature, concentration and variability of selected hazardous contaminants in the dry weather flow from the two pilot catchments.
3. To inventory the commercial and industrial establishments in each of the two selected catchments, in support of the predictions of HCs in this study and as data for other TAWMS studies.
4. To estimate the annual loading of HCs in each of the sewage flow components and in the total sewage flow originating in the selected catchments.
5. To implement interactive computer software enabling easy application of the HAZPRED model.

Predictive Methodology

The predictive methodology used in HAZPRED was developed at two levels of sophistication (Level I and Level II). Both model levels use the same basic approach in that wastewater quantities and HC concentrations are predicted from the summed contributions of the following wastewater components:

Residential Wastewater
Commercial Wastewater

Industrial Process and Sanitary Wastewater
Industrial Cooling Water
Dry Weather Infiltration

Level I methodology uses total industrial water-use data and applies a constant factor (i.e. a fraction of total water usage) to estimate industrial wastewater flows. No distinction is made between cooling waters and process wastewaters in the Level I procedures.

Level II methodology adds refinement in the prediction of industrial wastewater quantity by regarding cooling and process waters separately and enables prediction of the wastewater characteristics of individual industry groups as defined by their Standard Industrial Classification Code (SIC).

Data Collection

The field program was carried out in two catchments of very different sewerage, land use and industrial characteristics in the cities of York and North York. Data collection included basic catchment characterization as well as in-sewer flow measurements and sampling.

Extensive analytical effort was employed to develop accurate quantitative HC data. Mann Testing Laboratories provided all organics analyses, while MOE Laboratories provided metals and conventional analyses.

Catchment characteristics including observed dry weather flows are summarized below in Table ES-1.

TABLE ES-1. CATCHMENT CHARACTERISTICS

Catchment	York	North York
Area (ha)	147	354
Sewerage	Combined; pre-1960 installation	Separate; post - 1960 installation
Land-Use Distribution		
Residential	55%	0%
Commercial	11%	16%
Industrial	29%	84%
Other	≃ 5%	0%
Number of Industries and Major Commercial Establishments	13	≃ 600
Average Dry Weather Wastewater Flow (lpd)	2,151,000	6,463,000

Average dry weather concentrations of priority pollutants identified in the sanitary wastewaters from two catchments are presented in the following table.

TABLE ES-2. OBSERVED AVERAGE HC CONCENTRATIONS

GROUP/POLLUTANT	NORTH YORK AVERAGE OBSERVED CONCENTRATION (μg/l)	YORK AVERAGE OBSERVED CONCENTRATION (μg/l)
Purgeable		
Benzene	2.4	2.3
Chloroform	47	7.1
1,1 Dichloroethylene	17	ND
Dichloromethane	207	264
Ethyl Benzene	82	398
Tetrachloroethylene	13	<3.0
Toluene	447	120
1,1,1-Trichloroethane	15.5	<3.0
Trichloroethylene	83	ND
Extractable-Acid		
2,4-Dimethyl Phenol	13	<2.5
Phenol	8.2	<1.6
Extractable-Base Neutral		
Bis(2-Ethyl Hexyl) Phthalate	9.1	21
Butyl Benzyl Phthalate	0.9	7.9
Di-n Butyl Phthalate	22	6.4
Di-n-Octyl Phthalate	N.D.	<1.5
Dichlorobenzene	6.8	4.2
Napthalene	8.7	2.7
Phenanthrene	0.6	1.4
Metals and CN^-		
Cadmium	1620	5.8
Chromium	2844	47
Copper	228	118
Lead	153	121
Mercury	0.32	0.24
Nickel	49.8	1.2
Zinc	7655	224
Total CN^-	2982	12

N.D. = Not Detectable

In total, 9 purgeable compounds and 8 extractable compounds (2 Acid and 6 Base-Neutral) as well as seven selected metals and total cyanides were observed in quantifiable amounts in any sample at either monitoring site. The purgeable compounds and the phthalate esters were the most prevalent organics. The metals and cyanides exhibited the highest concentrations of all the priority pollutants.

Model Validation

Field data was used for model validation. Four tests of predictive accuracy were employed. Specifically, model predictions were compared with observations on the basis of the following:

1) Accuracy of predicting wastewater quantities.
2) Accuracy of predicting incidence of observed compounds i.e. number of compounds predicted but not detected, and number of compounds detected but not predicted).
3) Accuracy of predicting HC concentrations as measured by the number of predictions within 1 log and 1/2 log of observed results.
4) Accuracy of predicting HC loadings as measured by the number of predictions within 1 log and 1/2 log of observed results.

HAZPRED performance with respect to wastewater quantity is presented below:

TABLE ES-3. COMPARISON OF OBSERVED AND PREDICTED WASTEWATER QUANTITIES

CATCHMENT	MODEL LEVEL	RATIO PREDICTED/ OBSERVED
York	I	1.16
	II	1.20
North York	I	1.53
	II	1.29

Level II predictive accuracy was good in both catchments. Level I gave good results for York. North York predictions were however, considerably less accurate. This demonstrates the impact of cooling waters upon quantity predictions. In North York, cooling waters are returned to storm sewerage, and are thus, lost to the sanitary system. Level II modelling accounts for this loss, whereas, Level I does not. In York, cooling waters are returned to a common combined sewer, and hence, little difference in predictive accuracy is observed between model levels.

Both model levels gave similar performance when judged by the accuracy in predicting the incidence of HCs. Table ES-4 summarizes the comparison of the incidence of predicted and observed HCs.

TABLE ES-4. COMPARISON OF THE INCIDENCE OF OBSERVED AND PREDICTED HAZARDOUS CONTAMINANTS

CATCHMENT	MODEL LEVEL	PREDICTED/ NOT DETECTED	DETECTED/ NOT PREDICTED
York	I	10	3
	II	8	2
North York	I	9	2
	II	12	1

The majority of compounds predicted but not detected were purgeables. Observed and predicted incidence of the metals and total cyanide gave the best results with an exact match.

The final tests of model accuracy were based on quantitative measures comparing observed and predicted concentrations and loadings. The comparative data is presented in Table ES-5.

TABLE ES-5. COMPARISON OF OBSERVED AND PREDICTED HC CONCENTRATIONS AND LOADINGS

CATCHMENT	MODEL LEVEL	CRITERIA	CONCENTRATION No	CONCENTRATION %	LOADING No	LOADING %
York	I	1/2 log	14	41	16	47
		1 log	26	76	27	79
	II	1/2 log	17	50	20	59
		1 log	28	82	28	82
North York	I	1/2 log	12	32	12	32
		1 log	26	68	27	71
	II	1/2 log	11	29	16	42
		1 log	27	71	27	71

Notes: (1) % = Percent of total number of predicted values that fell within the given criteria of observed values.

Overall model predictive performance was quite good for both catchments particularly considering the industrial complexity of North York. Level II gave generally better accuracy, especially at the 1/2 log criteria.

Precicted Yearly HC Loadings

Predicted annual loadings of HCs for the York and North York catchments are presented in Tables ES-6 and ES-7 respectively. For the majority of HCs, industrial wastewater makes up the largest component of the total wastewater load. However, in York, the residential wastewater contribution is large and significant loadings of chloroform, phthalate esters and copper, lead, zinc, arsenic and antimony come from residential sources.

Recommendations

1) The HAZPRED data base should be refined through both additional literature review and field studies to incorporate data on non-characterized SIC groups. The scope of the data base should also be expanded to include organic pollutants of concern that are not presently on the EPA list.
2) Possible refinements to the HAZPRED data base should be investigated. Potential improvements requiring evaluation should include:
    i) The feasibility of dividing major SIC groups into sub-groups (e.g. SIC 3471 electroplating could be sub-divided according to the type of plating operation (i.e. precious metal, chrome, mixed, etc.) and of developing HC data specific to each sub-group.
    ii) The feasibility of developing HC concentration data within a SIC group or sub-group specific to industries with and without pretreatment.
3) The HAZPRED model should be further developed to enable prediction of HCs in stormwater runoff and combined sewer overflow. The overall model (wet & dry) should then be validated by a well designed data collection program in at least two catchments of diverse characteristics.

TABLE ES-6. PREDICTED ANNUAL HC LOADINGS - YORK CATCHMENT

CONTAMINANT	COMPONENT			
	RESIDENTIAL	COMMERCIAL	INDUSTRIAL	TOTAL
	kg/yr	kg/yr	kg/yr	kg/yr
Purgeable				
Acrylonitrile	0.00	0.00	22	22
Benzene	0.07	0.04	3.41	3.5
Bromodichloromethane	0.00	0.01	0.11	0.13
Carbon Tetrachloride	0.00	0.00	1.38	1.4
Chloroethane	0.00	0.00	8.9	8.9
Chloroform	1.00	0.10	0.70	1.8
1,2 Dichloroethane	0.03	0.00	0.27	0.31
1,1 Dichloroethylene	0.00	0.00	0.35	0.35
1,2-t Dichloroethylene	0.00	0.02	0.33	0.35
Dichloromethane	0.00	0.00	2.2	2.2
Ethyl Benzene	0.13	0.04	5.8	5.9
Tetrachloroethylene	2.09	0.31	2.36	4.77
Toluene	0.86	0.16	8.4	9.4
1,1,1 Trichloroethane	0.76	0.04	2.3	3.1
Trichloroethylene	0.13	0.19	0.77	1.1
Extractable-Acid				
2,4 Dimethyl Phenol	0.23	0.00	1.8	2.1
Pentachlorophenol	0.40	0.09	2.3	2.8
Phenol	1.9	0.07	43	6.3
Extractable Base-Neutral				
Bis (2-Ethyl Hexyl) Phthalate	2.3	0.11	2.5	4.9
Butyl Benzyl Phthalate	2.3	0.16	4.2	6.6
Di-n Butyl Phthalate	3.0	0.17	2.4	5.5
Dichlorobenzenes	0.93	0.11	9.3	10.4
Diethyl Phthalate	3.3	0.08	0.00	3.3
Naphthalene	0.70	0.04	1.4	2.1
Nitrobenzene	0.00	0.00	0.30	0.30
Metals and CN⁻				
Antimony	0.90	0.00	0.11	1.0
Arsenic	1.6	0.04	0.22	1.9
Cadmium	0.60	0.01	1.1	1.7
Chromium	5.4	0.83	19	26
Copper	24	0.80	4.9	30
Lead	32	0.73	11.6	45
Mercury	0.13	0.01	3.1	3.2
Nickel	1.4	0.18	3.8	5.4
Selenium	1.3	0.05	0.06	1.4
Silver	0.73	0.04	3.7	5.4
Zinc	71	2.0	64	137

TABLE ES-7. PREDICTED ANNUAL HC LOADINGS - NORTH YORK CATCHMENT

CONTAMINANT	COMPONENT		
	COMMERCIAL	INDUSTRIAL	TOTAL
	kg/yr	kg/yr	kg/yr
Purgeable			
Acrylonitrile	0.00	368	368
Benzene	1.4	52	53
Bromodichloromethane	0.53	2.5	3.0
Carbon Tetrachloride	0.05	48	48
Chlorobenzene	0.00	1.2	1.2
Chloroethane	0.00	152	152
Chloroform	3.5	23	27
Dibromochloromethane	0.37	2.8	3.2
1,1 Dichloroethane	0.05	2.9	2.9
1,2 Dichloroethane	0.05	7.5	7.6
1,1 Dichloroethylene	0.16	14.6	14.6
1,2-t Dichloroethylene	0.79	14.4	15.2
1,2 Dichloropropane	0.00	1.2	1.2
Dichloromethane	0.00	119	119
Ethyl Benzene	1.6	318	320
Tetrachloroethylene	11.3	93	105
Toluene	5.8	135	141
1,1,1 Trichloroethane	1.5	121	122
1,1,2 Trichloroethane	0.00	0.26	0.26
Trichloroethylene	6.8	69	76
Extractable-Acid			
2,4 Dimethyl Phenol	0.00	88	88
Pentachlorophenol	3.1	56	59
Phenol	2.4	176	178
Extractable Base-Neutral			
Bis (2-Ethyl Hexyl) Phthalate	4.1	72	77
Butyl Benzyl Phthalate	5.6	201	207
Di-n Butyl Phthalate	6.2	85	92
Dichlorobenzene	4.0	448	452
Diethyl Phthalate	3.0	0.43	3.4
Isophorone	0.00	1396	1396
Naphthalene	1.4	62	63
Metals and CN^-			
Antimony	0.16	26	26
Arsenic	1.4	6.3	7.7
Cadmium	0.32	75	75
Chromium	30	2253	2283
Copper	29	499	528
Lead	26	2423	2449
Mercury	0.21	26	26
Nickel	6.5	924	930
Selenium	1.7	1.8	3.5
Silver	1.5	179	181
Thallium	0.05	0.99	100
Zinc	73	2125	2192

1.0 INTRODUCTION

Modern urban society employs many inorganic and synthetic organic compounds which are ultimately discharged into municipal sanitary or combined sewer systems. A portion of these substances are hazardous in the sense that upon exposure they can affect human health or produce toxic conditions in the aquatic environment.

The inputs of hazardous contaminants (HCs) to sewer systems cause a variety of problems. In combined sewer areas or where sanitary bypass occurs from separated systems, HCs are sometimes released to the environment in an uncontrolled manner. Even where no direct discharges occur, some HCs may impair sewage treatment processes and can reduce the suitability of processed sludges for land application. Municipalities in recognition of these problems have adopted sewer-use bylaws which are in turn supported by enforcement programs. The basic tool of enforcement has been monitoring coupled with the experience of municipal staff.

Sewer-use regulation is, however, becoming increasingly complex as the number and nature of HCs requiring regulatory surveillance increases. Costs of monitoring are increasing particularly where complex organic analyses are required. Some means of setting monitoring priorities and of identifying likely HC species are needed. Moreover, sewer-use decisions often need to be made before an industry(s) is allowed to connect to existing sewerage. Prior knowledge of potential contaminant species, concentrations and loadings may point, for example, to the need for industrial pretreatment. In combined sewer areas, a methodology capable of predicting HC loadings to receiving waters is an essential impact assessment tool.

The ability to predict the incidence, concentration and loading of HCs in sewage systems is therefore of considerable practical value, the following summarizes some potential applications.

- Aid in developing new or augmented sewer use bylaws.
- Prediction of the nature, concentration and loading of HCs in combined sewer overflow or sanitary bypass.
- Prediction of the impact upon sewage quality of new industry or of developing areas.

- Assessment of the relative contribution of HCs from existing sewer areas. This may be of considerable interest to metropolitan governments or municipalities accepting sewage imputs from outside their political boundaries.
- Prediction of total HC loadings and their distribution by sewer catchments incoming to sewage treatment facilities.

In recognition of the above needs and with a specific interest in predicting HCs in combined sewer overflow the Ontario Ministry of the Environment through the Toronto Area Watershed Management Study, initiated this study. The broad objective was the development of a predictive methodology describing the incidence, concentration and loading of HCs in C.S.O. applicable to the Toronto area.

This report presents the first phase of development of the Wastewater Hazardous Contaminant Predictive Model (HAZPRED) in which the predictive methodology for dry weather sewage flows is developed and validated. The second and third study phases will address the extension of the dry weather methodology to overflows and the predictions of HC loads and concentrations in C.S.O.within the study area, respectively. The later phases will be carried out and reported separately.

2.0 PROJECT OBJECTIVES AND SCOPE

2.1 Project Objectives

The overall objective of this project was the development of a methodology for predicting HCs in dry weather sewage flows. Since data was available only for the EPA list of 129 priority pollutants, modelling was restricted to these contaminants. In order to make the methodology readily useable, it was decided to implement it as an interactive computer program. Coupled with model development was the need to provide observed data for model validation. Hence a field program supported by extensive analytical effort was instituted to provide a suitable validation data base. Specifically the project objectives were:

1. To develop a methodology that can be used to predict the incidence of the dominant EPA priority pollutants and their concentrations and loadings (to within an order of magnitude in dry weather sewage flow), and to verify this predictive methodology by a well designed field sampling program in two selected catchments of diverse characteristics.
2. To characterize the nature, average concentration and variability of selected hazardous contaminants in the dry weather flow from the two pilot catchments.
3. To inventory the commercial and industrial establishements in each of the two selected catchments. This was done in support of the predictions of HCs in this study and as data for other TAWMS studies.
4. To estimate the annual loading of HCs in each of the sewage flow components and in the total sewage flow originating in the selected catchments.
5. To implement interactive computer software enabling easy application of the HAZPRED model.

It must be emphasized that neither the HAZPRED model nor the present study was intended to assess the environmental or health significance of the incidence of HCs in sanitary wastewaters. Moreover, it should be remembered that all HC results (observed or predicted) presented in the following report pertain to sanitary wastewaters as found in sewerage systems before receiving treatment at a municipal water pollution control plant.

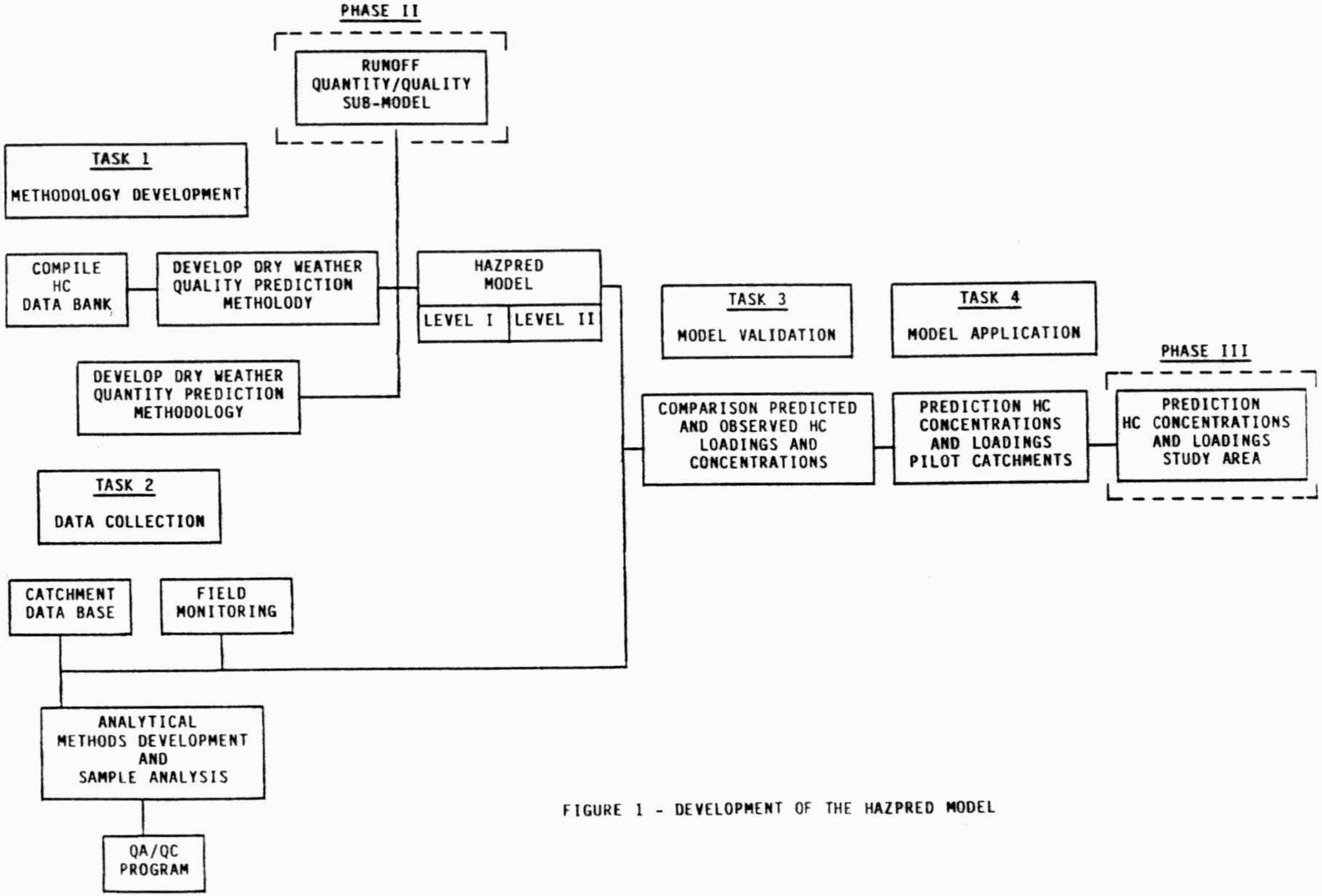

PHASE II
RUNOFF QUANTITY/QUALITY SUB-MODEL
TASK 1
METHODOLOGY DEVELOPMENT
COMPILE HC DATA BANK
DEVELOP DRY WEATHER QUALITY PREDICTION METHOLODY
HAZPRED MODEL
LEVEL I
LEVEL II
DEVELOP DRY WEATHER QUANTITY PREDICTION METHODOLOGY
TASK 3
MODEL VALIDATION
TASK 4
MODEL APPLICATION
PHASE III
COMPARISON PREDICTED AND OBSERVED HC LOADINGS AND CONCENTRATIONS
PREDICTION HC CONCENTRATIONS AND LOADINGS PILOT CATCHMENTS
PREDICTION HC CONCENTRATIONS AND LOADINGS STUDY AREA
TASK 2
DATA COLLECTION
CATCHMENT DATA BASE
FIELD MONITORING
ANALYTICAL METHODS DEVELOPMENT AND SAMPLE ANALYSIS
QA/QC PROGRAM

FIGURE 1 - DEVELOPMENT OF THE HAZPRED MODEL

2.2 Project Overview

An overview of Phase I study tasks and their relationship to other study phases is depicted in Figure 1. Two levels of application have been developed for the dry weather portion of HAZPRED. Level I procedures enable estimation with a minimum of data collection but do not account for the impact of specific large industries or industrial groups upon HCs. In additon, less sophisticated procedures are used for the estimation of industrial wastewater quantities. Level II procedures add significant refinements but at the expense of increased data needs.

The following outlines the four major study tasks.

Task 1 - Methodology Development

Methods were developed for the prediction of dry weather wastewater flow quantities and the dry weather wastewater concentrations of selected HCs. The methodology was implemented at two levels of sophistication.

Task 2 - Data Collection

The data necessary for model implementation and validation was collected. This task was further broken down into the following sub-tasks.

Sub-Task 2.1 - Catchment Data Base

In order to fulfill the needs of both model implementation and other TAWMS programs, an extensive data base describing the characteristics of the two pilot catchments was assembled. Information collected included:

- land-use distribution
- residential population
- number, location and nature of industrial establishments
- number and location of commercial establishments
- catchment sanitary sewerage boundaries
- water useage by residential, commercial and industrial category.

Sub-Task 2.2 - Field Data Collection

Model validation required field observations and sewage samples to provide a basis for estimating model accuracy. In-sewer flow measurements and wastewater samples were taken at the outlet of each catchment. Climatological observations included factors influencing sewage quantity or quality (i.e. precipitation or snow melt events).

Sub-Task 2.3 - Sample Analysis

Analysis of samples for trace organics were carried out under sub-contract by Mann Testing Labortories. Part of the sub-contract effort was devoted to developing the extraction techniques and instrumental procedures needed to provide quantitative analytical results. Conventional parameter and metals analyses were carried out by the MOE Laboratories using their routine procedures.

Task 3 - Model Validation

Once model algorithms were in place, a interactive computer program was prepared for both Level I and Level II methods. The output of the computer modelling for the pilot catchments was then compared with observed results.

Task 4 - Model Application

Estimates of annual HC sewage loadings from residential, commercial and industrial sources, and for the total sewage flow were prepared for each of the pilot catchments.

3.0 PREDICTIVE METHODOLOGY

3.1 General Considerations

The estimation of wastewater HC concentrations requires knowledge of the factors influencing wastewater quantity as well as wastewater quality.

The quantity of dry weather sewage flow from a given area is dependent both upon the nature of land-use activity in the area and upon the influx of groundwater through infiltration. Land-use as it pertains to flow estimation is broadly categorized as residential, industrial or commercial. In each case somewhat different techniques are required to develop the actual sewage flow components. A distinction should be made between flow estimates normally used for sanitary sewer or treatment facility design and those that have application in a predictive model. Design values in general tend to be conservative producing, quite often, substantially higher than observed flow values.

Figure 2 shows the components making up sanitary sewage in dry weather and indicates the factors that affect the magnitude of each component. Residential flows are dependent upon the total population served and are proportionate to, although not equal to, residential water consumption. Commercial flows are the sum of water consumed for all commercial establishments in a catchment. Industrial flows are the most difficult to characterize. Water supplied to an industrial establishement can finish incorporated into the industry's product (e.g. bottled soft drinks), in separate sewer areas as cooling water returned to a storm sewer, as water lost in process (e.g. evaporation) or as process and sanitary wastewater discharged to a sanitary or combined sewer. It is the last component of industrial water usage that is of most interest for the prediction of HC quantities. Dry weather infiltration (DWI) is the product of groundwater seepage through poor pipe joints and cracked piping and appurtenances. The quantity of DWI is related both to groundwater and soil conditions as well as the structural condition of the sewerage.

Land-use activity also influences HC concentrations. Industry, in particular, can have a disproportionate impact upon sewage quality. The important variables are the type of industry within the catchment and the nature of industrial practice(s) (i.e. pretreatment of process wastewaters; segregation of cooling waters; batch versus continuous release of wastes, etc.).

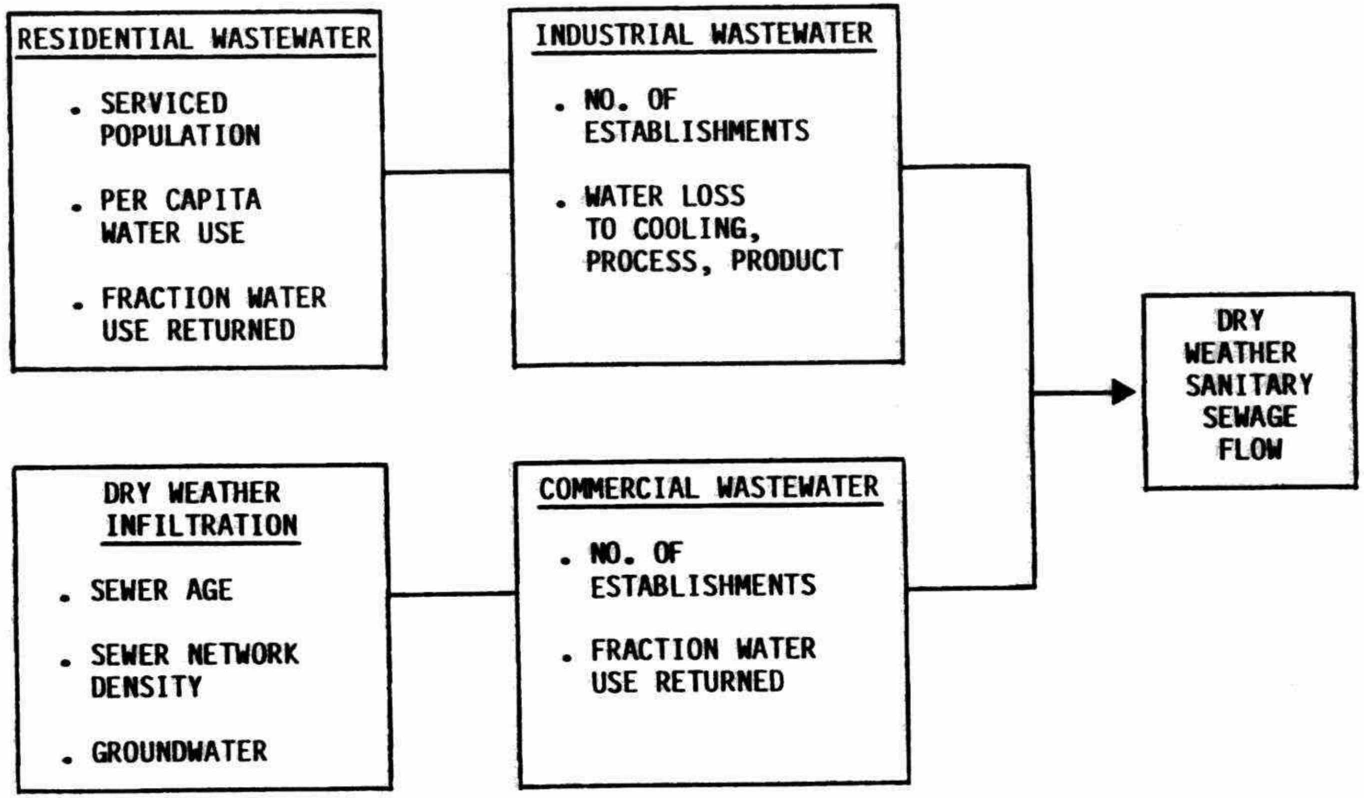


FIGURE 2 - COMPONENTS OF DRY WEATHER SANITARY SEWAGE

3.2 Estimation of Wastewater Quantities - Level I

3.2.1 Level I - Total Wastewater Flow

The total wastewater flow for Level I is given by equation 3-1 as follows:

$$Q_{TOT_1} = POP.RWW + CWW + IWW + DWI_1 \qquad 3\text{-}1$$

where:

Q_{TOT_1} = Level I - total wastewater flow (lpd).
POP = sewered population.
RWW = residential per capita wastewater flow (lpcd).
CWW = commercial wastewater flow (lpd).
IWW = industrial wastewater flow (lpd) (sanitary and process).
DWI_1 = Level I - dry weather infiltration (lpd).

The following sections describe the means of estimating the individual wastewater flow component quantity and quality at both levels of model application.

3.2.2 Level I - Residential Wastewater Flow (POP.RWW)

The residential per capita wastewater flow rate is ideally developed from metered water use data. Winter data is used since it reflects most accurately water returned to the sanitary sewer. Summer time activities such as lawn watering, car washing etc., add to water use but not to sewer flows. Where household metering is not employed, water use data can be developed through the installation of test meters in selected households. Alternately flow data from a suitable pumping facility can be used. Some allowance for water loss in distribution must be applied to pumping station data. An allowance of 10-15% is considered typical (1) for "unaccounted" water (water lost in distribution).

Population data for a given catchment is developed from the most recent census figures. Since census and catchment boundaries may not match, the catchment population is estimated from unit area population of the census zone(s) and the catchment area.

3.2.3 Level I - Commercial Wastewater Flow (CWW)

In the HAZPRED model, it is assumed that the quantity of wastewater from commercial establishments is exactly equal to the commercial water usage. Water usage data, are again, ideally derived from individual metered records. Since the type of commercial establishments is not differentiated, commercial water usage is simply summed for a given catchment area.

Both Level I and Level II procedures of HAZPRED use the same methodology for estimation.

3.2.4 Level I - Industrial Wastewater Flow (IWW)

The relationship of water consumed to wastewater generated is considerably more complex for industrial establishments. Figure 3 illustrates the possible fate of supplied water entering an industry.

Level I modelling requires only the knowledge of total industrial water consumption for the catchment. Resident industries are first identified either from listings such as Scott's Directory (2) or by field inspection. The latter method is more comprehensive particularly for small establishments but can be quite manpower intensive. Once the industrial inventory is complete then water consumption records are accessed and a total industrial water usage is computed. The quantity of industrial wastewater is assumed to be a fixed proportion of water supplied. Based upon literature values (3) a return factor of 85% is suggested, although a return factor based upon knowledge of local industry is preferred. The industrial wastewater flowrate is given by the following expression:

$$IWW = RF \sum_{j=1}^{n} QWI_j \qquad 3\text{-}2$$

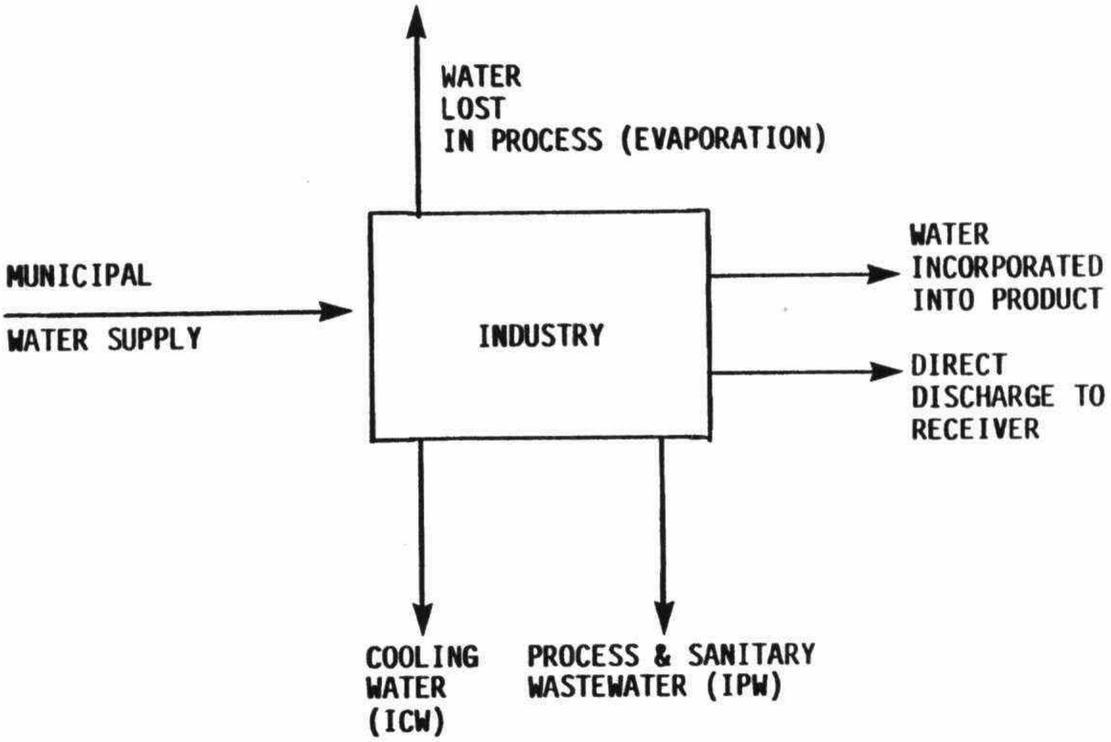
where:

RF = industrial water return factor (0.85) and

QWI_j = the water used by the j^{th} industry (lpd).

3.2.5 Level I - Dry Weather Infiltration (DWI_1)

Dry weather infiltration (DWI_1) is determined most accurately from metered dry weather flow data obtained at the catchment outlet and the computed residential, commercial and industrial wastewater flow components. This gives the following expression:



COMBINED SEWERAGE:	TO COMBINED SEWER	TO COMBINED SEWER
SEPARATE SEWERAGE:	TO STORM SEWER (NORMALLY)	TO SANITARY SEWER

FIGURE 3 - INDUSTRIAL WATER-USE RELATIONSHIPS

$$DWI_1 = QDW - [(POP.RWW) + CWW + IWW] \qquad 3\text{-}3$$

where:

QDW = observed dry weather flow at catchment outlet (lpd).

Since monitored data is, however, only rarely available, DWI rates are usually estimated. MOE experience (4) has shown a reasonable infiltration allowance to be between 91 and 227 lpd. The exact magnitude is determined subjectively from knowledge of the age of the sewer system and population. The same range of DWI values are used for both levels of model application.

3.3 Estimation of Wastewater Quantities - Level II

3.3.1 Level II - Total Wastewater Flow

The total wastewater flow for Level II is estimated by equation 3-4.

$$Q_{TOT_2} = POP.RWW + CWW + \sum_{k=1}^{m} IPW_k + \sum_{k=1}^{m} ICW_k + DWI_2 \qquad 3\text{-}4$$

where

Q_{TOT_2} = Level II - total wastewater flow (lpd).

IPW_k = total industrial process and sanitary wastewater discharged by the industries in the k^{th} SIC group (lpd).

ICW_k = total cooling water discharged by the industries in the kth SIC group into a sanitary or combined sewer. ICW = 0, if cooling water is discharged into a separated storm sewer or directly to a receiving water (lpd).

DWI_2 = Level II - dry weather infiltration (lpd).

The remaining parameters are defined in the same manner as in equation 3-1.

3.3.2 Level II - Residential (POP.RWW) and Commercial Wastewater Flow (CCW)

Level II uses the same procedures for estimating the residential and commercial wastewater flowrates as are employed by Level I.

3.3.3 Level II - Industrial Process and Sanitary Wastewater (IPW) and Cooling Water (ICW) Quantities

Level II procedures for industrial flows also start by compiling an industrial inventory. However, the industries listed are now segregated into sublists based on industry type as defined by the Standard Industrial Category code (SIC code). In the event that industries are identified by field inspection, the SIC category is determined by direct contact with the industry. Major industrial water users (>1% of the total industrial water use for the catchment) are identified in each SIC sub-list and are then contacted in order to estimate the wastewater flow components of interest. In the case of combined sewer catchments, the process and sanitary flows as well as the cooling water flows are identified. For separated sewerage systems, only the process and sanitary component is normally needed. Although where municipalities allow cooling water discharge to sanitary sewers estimation of both components will again be necessary. Occasionally, the wastewater or cooling water flow estimates may not be readily available from the industry. Best estimates of these flow components based upon previous experience or knowledge of the industry are then employed.

The Level II industrial wastewater flows generated by minor water users are estimated for each SIC category by equation 3-2 using a return factor of 0.85. The Level II expressions for cooling water and industrial process and sanitary for major water users flow are given in equations 3-5 and 3-6 respectively as follows:

$$ICW = \sum_{k=1}^{m} ICW_k \qquad 3\text{-}5$$

where:

ICW_k = the industrial cooling water flow for the major water using industries in the kth SIC group (lpd), and

$$IPW = \sum_{k=1}^{m} IPW_k + RF \sum_{k=1}^{m} QWI_k \qquad 3\text{-}6$$

where:

IPW_k = the industrial process and sanitary wastewater flow for major water using industries in the kth SIC group (lpd).

QWI_k = the water usage of the minor water using industries in the kth SIC group (lpd).

RF = industrial water return factor (0.85 unless otherwise specified).

3.3.4 Level II - Dry Weather Infiltration (DWI_2)

DWI_2 is also best estimated according to the following equation:

$$DWI_2 = QDW - [(POP.RWW) + CWW + \sum_{k=1}^{m} (IPW_k + ICW_k^*)] \qquad 3\text{-}7$$

* Included where applicable

In the absence of field data, DWI_2 is assumed equal to DWI, and can take on a value between 91 and 227 lpcd.

3.4 Estimation of Hazardous Contaminant Concentrations - Level I

Level I estimates of HC concentrations in the residential, commercial and industrial components of wastewater are based on a 1979 U.S. EPA funded study carried out by A.D. Little(5). The objective of the Little study was to determine the relative significance of source (residential, commercial or industrial) contributions of the EPA designated priority pollutants to publicly owned treatment works. Specifically, the study hoped to identify which priority pollutants originated from a given source (and which did not) and with what frequency. In the course of the study, the A.D. Little team examined areas within four U.S. cities including:

Muddy Creek Drainage Basin, Cincinnati, Ohio
Coldwater Creek Drainage Basin, St. Louis, Missouri
R.M. Clayton Drainage Basin, Atlanta, Georgia
Hartford WPCP Drainage Basin, Hartford Connecticut

Within each basin, a number of smaller catchment areas were identified as predominantly residential, commercial or industrial in nature. Altogether, eleven residential, ten commercial and six industrial areas were identified. Priority pollutants found in the wastewater from each of these small catchment areas and in tapwater samples from the four cities are summarized in Table 1. The overall list of EPA priority pollutants is given in Appendix 1. Compounds other than those presented in Table 1 were detected, but because of quality control problems, no quantitative data were available. Dichloromethane is perhaps the most significant compound in this group.

TABLE 1. OVERALL AVERAGE CONCENTRATIONS OF OBSERVED PRIORITY POLLUTANTS [A.D. LITTLE, 1979 (5)]

POLLUTANT NAME	TAP (1) WATER		RESIDENTIAL (1) AREAS		COMMERCIAL (1) AREAS		INDUSTRIAL (1) AREAS	
	Avg.	S.D.	Avg.	S.D.	Avg.	S.D.	Avg.	Range
1,1-Dichloroethylene	.0	.0	.0	.0	.3	.5	11.6	0 - 49
1,1-Dichloroethane	.0	.0	.0	.0	.1	.1	1.6	0 - 8
1,2-t Dichloroethylene	.0	.0	.0	.0	1.5	2.0	11.7	0 - 57
Chloroform	27.1	8.6	3.0	.9	6.7	2.0	12.0	5 - 20
1,2-Dichloroethane	.0	.0	.1	.1	.1	.2	.6	0 - 2
1,1,1-Trichloroethane	.6	1.3	2.3	2.8	2.9	1.8	85.1	0 - 252
Carbon Tetrachloride	.0	.0	.0	.0	.1	.2	28.4	0 - 152
Bromodichloromethane	8.8	6.9	.0	.1	1.0	1.2	1.6	0 - 4
Trichloroethylene	.0	.0	.4	.5	12.8	25.6	25.4	4 - 68
Benzene	.0	.0	.2	.4	2.7	2.1	1.2	0.6 - 2
Dibromochloromethane	5.9	7.1	.0	.0	.7	.9	1.2	0 - 3
Bromoform	.8	.9	.0	.0	.0	.0	.0	0
1,1,2,2-Tetrachloroethylene	.8	.9	6.3	7.6	21.4	13.3	69.9	14 - 205
Toluene	.3	.5	2.6	2.7	11.0	6.8	52.3	5 - 124
Chlorobenzene	.0	.0	.1	.1	.0	.1	.9	0 - 6
Ethyl Benzene	.1	.1	.4	.5	3.0	3.1	100.4	1 - 258
Phenol	.0	.0	5.8	5.6	4.5	.8	135.8	0 - 552
2,4-Dimethyl Phenol	.0	.0	.7	.8	.0	.0	74.0	0 - 301
Pentachlorophenol	.0	.0	1.2	2.4	5.8	11.5	10.1	0 - 51
Dichlorobenzenes (2)	.0	.0	2.8	5.5	7.5	11.3	376.5	0 - 2188
Naphthalene	.0	.0	2.1	2.9	2.6	3.2	50.7	0 - 195
Diethyl Phthalate	.8	1.6	9.8	11.6	5.7	7.0	.0	0
Di-n-Butyl Phthalate	4.5	6.7	9.0	6.5	11.7	11.2	67.1	0 - 99
Butyl Benzyl Phthalate	.0	.0	6.8	7.5	10.6	3.3	168.2	0 - 604
Bis(2-Ethyl Hexyl) Phthalate	4.1	8.3	6.8	8.1	7.7	7.4	43.0	0 - 174
Antimony	3.0	6.0	2.7	3.8	.3	.4	1.7	0 - 9
Arsenic	1.6	3.1	4.8	8.7	2.6	4.2	3.2	0 - 9
Cadmium	.5	1.0	1.8	1.6	.6	.9	20.7	2 - 84
Chromium	2.5	5.0	16.3	6.1	56.8	84.0	713.2	18 - 2137
Copper	28.4	21.0	72.1	32.4	54.5	21.2	124.8	42 - 343
Lead	10.4	13.5	97.3	135.8	49.8	32.8	323.7	78 - 1225
Manganese	5.1	3.4	153.0	50.2	224.8	106.2	232.1	60 - 441
Mercury	.0	.0	.4	.5	.4	.4	1.9	0 - 6
Nickel	4.3	6.1	4.2	3.7	12.4	3.9	108.7	6 - 597
Selenium	2.9	3.8	3.8	4.7	3.3	4.2	.9	0 - 3
Silver	.3	.5	2.2	2.5	2.9	3.0	150.4	3 - 567
Thallium	.0	.0	.0	.0	.1	.2	.1	0
Zinc	66.9	95.6	214.0	175.7	138.1	30.3	860.0	122 - 3356
Total Cyanides	.0	.0	1.1	1.8	.2	.4	90.7	2 - 236
Total Phenols	2.0	4.0	30.8	11.3	37.0	4.0	204.1	26 - 515

S.D. = Standard Deviation

(1) = All concentrations are in μg/l.

(2) = Dichlorobenzenes are reported as a group rather than as individual isomers(3).

The Table shows that wastewaters from the industrial catchments, in virtually all cases, contain higher concentrations of priority pollutants. The notable exceptions are benzene which appears in higher concentrations in the commercial areas studied and some volatile compounds (bromodichloromethane, chlorodibromomethane, chloroform and bromoform) which have the highest concentrations in the tap waters studied.

Equally of interest are the pollutants never or rarely detected in any of the A.D. Little test sites. Table 2 presents the listing of the 70 pollutants either never detected or detected fewer than 3 times in any city during the course of the study. It is noteworthy that no PCBs pesticides or PAHs (e.g. anthracene, phenanthrene) were detected in any of the study sites.

For purposes of modelling, the Table 1 data provide the average concentrations of HCs in the residential commercial and industrial components of wastewater flow (RC_i, CC_i, IC_i) for use in equation 3-8 which gives the total mass loading rate of a specific HC as follows:

$$M_{TOT_i-1} = \frac{POP.RWW.RC_i + CWW.CC_i + IWW.IC_i}{1{,}000{,}000} \qquad 3\text{-}8$$

where:

M_{TOT_i-1} = Level I - total mass rate of the ith HC (gm/day).

RC_i = concentration of the ith HC in the residential component of wastewater (μg/l).

CC_i = concentration of the ith HC in the commercial component of wastewater (μg/l).

IC_i = concentration of the ith HC in the industrial component of wastewater (μg/l).

Equation 3-9 then gives the wastewater concentration of the ith HC:

$$C_{i-1} = \frac{M_{TOT_i-1}}{Q_{TOT_1}} \qquad 3\text{-}9$$

where:

C_{i-1} = Level I - concentration of the ith HC in the total wastewater flow.

The dry weather infiltration DWI, is assumed to contain no contaminants.

TABLE 2. POLLUTANTS NEVER OR INFREQUENTLY DETECTED IN THE A.D. LITTLE STUDY

PURGEABLE

Chloromethane
Dichlorodifluoromethane
Bromomethane
Acrolein
Cis-1,3-Dichloropropylene
Vinyl Chloride
Chloroethane
Trichlorofluoromethane
Acrylonitrile
1,2-Dichloropropane
Trans-1,3-Dichloropropylene
1,1,2-Trichloroethane
1,1,2,2-Tetrachloroethane

EXTRACTABLE-ACID

Nitrophenol
2,4 Dinitrophenol
4,6 Dinitro-2-cresol
4 Nitrophenol
2 Chlorophenol
2,4 Dichlorophenol
2,4,6 Trichlorophenol
4 Chloro-3-Cresol

EXTRACTABLE-BASE NEUTRAL

Hexachloroethane
Bis(chloromethyl) Ether
Bis(2-chloroisopropyl) Ether
N-Nitrosodimethylamine
Nitrosodimethylamine
Hexachlorobutadiene
2 Chloroethyl Vinyl Ether
Bis(2-Chloroethoxy) Methane
Isophorone
Hexachlorocyclopentadiene
2 Chloronaphthalene
Acenaphthylene
Acenaphthene
Dimethyl Phthalate
2,6-Dinitrotoluene
4-Chlorophenyl Phenyl Ether
Fluorene

EXTRACTABLE-BASE NEUTRAL (CONT'D)

2,4 Dinitrotoluene
1,2 Diphenylhydrazine
N-Nitrosodiphenylamine
Hexachlorobenzene
4-Bromophenyl Phenyl Ether
Benzidine

PESTICIDES AND PCBs

Alpha-BHC
Gamma-BHC
Beta-BHC
Delta-BHC
Heptachlor Epoxide
Endosulfan I.
DDE
Dieldrin
Endrin
DDD
Endosulfan II.
DDT
Endrin Aldehyde
Endosulfan Sulfate
Heptachlor
Aldrin
Chlordane
Toxaphene
PCB-1221
PCB-1232
PCB-1242
PCB-1248
PCB-1254
PCB-1260
PCB-1016

METALS AND CYANIDE

Beryllium

TOTAL 70 POLLUTANTS

3.5 Estimation of Hazardous Contaminant Concentrations - Level II

One weakness of the above estimation procedure is the lack of discrimination for the type of industry present or anticipated in a given catchment. Clearly, although both an organic chemical manufacturer and an electroplater may discharge similar wastewater quantities the species and concentration of contaminants would be different.

Level II procedures, wherever possible, use contaminant concentrations specific to the categories of industry present in the catchments. However, only a limited number of industrial effluents have to date received characterization. The most comprehensive industrial effluent data base is the EPA's Treatability Manual (6). The manual is the product of extensive monitoring and gives the incidence and effluent concentration of EPA priority pollutants for certain types of industry. The industry categories and their respective SIC codes covered by the Manual are given in Table 3. As can be seen, some industry groups are included which would have limited application for the present study. Consequently HC data was abstracted for only selected SIC groups. Table 4 presents the industrial categories for which HC data is presently included in the Level II HAZPRED model.

Noteworthy aspects of the Level II HC data base are as follows:

- Data for SIC groups 2821, 2823 and 2824 were not available in the Treatability Manual, but were obtained from EPA effluent standard development documents (7) for the resin and synthetic fibre industry.
- Auto and other laundries (car washes, laundromats, commercial laundries, etc.) were considered commercial estalishments which would be represented by the commercial wastewater component.
- Concentration ranges for certain contaminants given in the manual are quite wide. For example, electroplating effluents because of differences in industry practice (e.g. degree of treatment of wastewater, type of process, housekeeping) are particularly prone to variation.
- In some instances, wastewater characteristics for a number of industry sub-categories have been polled to give an overall average for the category as a whole. In other cases where sub-categories

TABLE 3. INDUSTRY CATEGORIES COVERED BY EPA TREATABILITY MANUAL

SIC CODE(s)	INDUSTRY CATEGORY
7211, 7213, 7214, 7215, 7216, 7217, 7218, 7219, 7542	Auto and Other Laundries
1111, 1112, 1211, 1213	Coal Mining
3471	Electroplating
2812, 2813, 2816, 2819	Inorganic Chemicals
3312, 3315, 3316, 3317	Iron & Steel Manufacture
3111	Leather Tanning and Finishing
3479	Coil Coating (metal coating)
3321, 3322, 3324, 3325 3361, 3362, 3369	Foundaries (Ferrous and Non-Ferrous)
3431	Porcelain Enamelling (metal coating)
2892	Explosives Manufacture
2861	Gum and Wood Chemicals
2831, 2833, 2834, 2844	Pharmaceutical Manufacture
*333_, *334_	Non-Ferrous Metals Manufacture (primary and secondary smelting and refining)
*10__	Ore Mining and Dressing
2851, 2893	Paint and Ink Formulation
2911	Petrolium Refining
2611, 2621, 2631	Pulp, Paper and Paperboard Mills
2822, 3011, 3021, 3031 3041, 3069, 3293	Rubber Processing
2841	Soap and Detergent Manufacture
4911, 4931	Steam and Electric Power Generating
*22__, *23__	Textile Mills
2491	Timber Products Processing

* - covers all SIC codes in group.

TABLE 4. INDUSTRIAL CATEGORIES INCLUDED IN THE LEVEL II MODEL

SIC DESIGNATION	INDUSTRIAL DESCRIPTION
2200 - 2299	Textile Mill Products - receiving and preparing fibres - yarn, thread, webbing manufacture - fabric manufacture and finishing
2821, 2823, 2824	Plastics Manufacture - plastic materials, synthetic resins - cellulosic man-made fibres - synthetic organic fibres
2834	Pharmaceuticals - other than perfumes and cosmetics
2841	Soaps and Detergents - manufacture soap, synthetic organic detergents, organic alkaline, detergents and crude and refined glycerine
2844	Cosmetic Preparations - preparations which function as skin treatments excludes those used to enhance appearance
2851	Paint Manufacture - trade-sales paints, chemical coatings, varnishes and lacquers - miscellaneous products such as epoxy coatings, paint removals, stains
2893	Printing Ink - letterpress, lithographic, flexographic and gravure inks - varnish

TABLE 4 (CONT'D). INDUSTRIAL CATEGORIES INCLUDED IN THE LEVEL II MODEL

SIC DESIGNATION	INDUSTRIAL DESCRIPTION
3011 - 3079*	Rubber Processing - tire and inner tube manufacture - rubber footwear - reclaimed rubber - rubber hose and belting - other fabricated rubber products
3111	Leather Tanning and Finishing - conversion of animal skins or hides to leather
3312	Coke Byproducts - manufacture of light oils, tars, phenolates etc. as byproducts of coking
3321 - 3325	Foundries - melting, moulding or finishing of iron, steel, aluminum, brass, copper and other metals
3431	Porcelain Enamelling - application of glass-like coating to steel, iron, aluminum or copper
3471	Electroplating - application of metallic surface coating by electrodeposition
3479	Coil Coating - painting of coiled sheet metals

* SIC-3079 included in this group since products are related.

were felt to be sufficient importance and where data was available, the sub-category wastewater characteristics were included under the sub-category SIC designation.

- The HAZPRED data base is flexible such that when additional data for other SIC groups becomes available it can be readily added to the data base.

The matrix of HC concentrations for each SIC group listed in Table 4 is presented in Appendix 2.

The average industrial HC concentrations presented in Table 1 are used in Level II to characterize SIC groups not represented in Table 4. No refinement over Level I procedures was felt necessary or indeed feasible for estimation of HC concentrations in the residential and commercial wastewater components. Consequently, Table 1 data are also employed for Level II modelling.

The total mass loading rate of specific HCs estimated by Level II procedures is then given by:

$$M_{TOT_i\text{-}2} = \frac{POP.RWW.RC_i + CWW.CC_i + \sum_{k=1}^{m} IPW_k.IC_{i,k}}{Q_{TOT\text{-}2}} \qquad 3\text{-}10$$

where:

$M_{TOT_i\text{-}2}$ = Level II - total mass rate of the ith HC (gm/day).

$IC_{i,k}$ = average concentration of the ith HC in the effluent discharged by the industries of the kth SIC group.

Industrial cooling water (ICW) and dry weather infiltration (DWI) are assumed to contain no contaminants.

The Level II concentration ($C_{i\text{-}2}$) of the ith HC is as follows:

$$C_{i\text{-}2} = \frac{M_{TOT_i\text{-}2}}{Q_{TOT\text{-}2}} \qquad 3\text{-}11$$

4.0 DATA COLLECTION AND ANALYTICAL METHODOLOGY

4.1 Catchment Data Base

Data collection procedures varied little from those described in the previous section. The following provides a synopsis of the key features of assembling the catchment data bases for the North York and York study areas.

Catchment Boundaries: Catchment boundaries were delineated from examination of sanitary sewer maps and through discussion with municipal officials.

Catchment Popultation: Catchment residential population was determined only for the City of York catchment. The North York area was industrial with a significant commercial component.

Population data for York was obtained from 1980 census figures. Census districts did not match catchment boundaries and consequently area weighted estimates were used to assess the catchment residential population.

Water Usage: For both catchments, metered water consumption data was available for all land-use categores. Average residential consumption for the York catchment was developed from analysis of characteristic areas within the catchment.

Number, Location and Category of Industries: The name and location of all industrial establishments in both catchments were determined by on-site inspection because of the need for up-to-date verified information for this study and other TAWMS activities. The industrial category (SIC group) of all industries was determined from the 1982 Scott's Directory. In some cases industries were not listed in Scott's, and unless the nature of the industry was obvious from its name they were included in the "OTHER" SIC category.

Number and Location of Commercial Establishement: The inventory of commercial establishments in each catchment was also prepared through on-site inspection. Only major commercial establishments were identified in the York catchment.

4.2 Field Data Collection

Based upon examination of sewer maps and subsequent field inspection monitoring locations were identified near the outlets of both catchments. Automatic sampling and flow measurement apparatus were then installed in the selected manholes.

Twenty-four hour composite samples were collected at both study sites between March 14-29, 1983 for analysis of gross parameters, metals and extractable organics. Grab samples had to be substituted in place of the composite sample on a number of occasions because of sampler malfunction. Sample bottles were filled to slight overflow and then carefully capped to ensure no air entrainment. Wastewater grab samples for purgeable organics were collected in 250 mL amber glass bottles equipped with Tuf-bond discs and screw caps fitted with a syringe access hole. Before use, all bottles were cleaned and heated at 400°C for 24 hours. They were then purged with nitrogen and sealed before use. All samples were stored at 4°C until analyzed.

All trace organics analyses were conducted by Mann Testing Laboratories. Grab samples for purgeable analysis were delivered to Mann Testing Labs on the morning of collection. Samples for extractable organics were returned to the main CANVIRO laboratory in Kitchener for extraction and concentration within 7 days of collection.

In-sewer level measurements were continuously taken during the sampling period. Level data were converted to flowrates with the Chezy-Manning formula. The formula was "calibrated" for each site by means of velocity measurements.

General climatological observations were noted by field staff. Precipitation and temperature data were taken from the Environment Canada Toronto Bloor Street Station.

4.3 Analytical Methodology

4.3.1 Organics Analyses

4.3.1.1 Organic Pollutant Categories

Organics analyses were carried out using modified EPA priority pollutant methods.

The three major categories of organics analyzed were:

a) Purgeables - volatile aromatics
- low molecular weight hydrocarbons
- haloethers

b) Extractables
  i) Acidic Fraction - phenolic compounds
    - carboxylic acids
  ii) Base Neutral Fraction - polynuclear aromatics (PAH)
    - chlorinated aromatics
    - phthalate esters
    - haloethers
    - nitrosamines
    - pesticides
    - PCBs

Because the analytical results would be used for model validation it was critical to establish a high degree of confidence in the quantitation of organics. As a result, an extensive QA/QC program was instituted. The following sections give an overview of the analytical program. For details of organics analysis, reference should be made to the Mann Testing report (8).

4.3.1.2 Purgeable Organics

Analysis of volatile organics in wastewater was conducted using a UNACON 780B automatic concentrator (Envirochem Inc., Kemblesville, P.A.). This instrument utilized the technique developed by Bellar and Lichtenberg for the isolation and concentration of volatiles for chromatographic analysis. In general, this process involved gas stripping of the sample and adsorption of the organic compounds on a sorbent trap followed by thermal desorption and analysis by gas chromatography or gas chromatography/mass spectrometry.

Volatile organics were analyzed from 10 mL aliquots of the wastewater samples within seven days after delivery. Since it was suggested in other studies that elevating the temperature during sparging could enhance the recovery, the purging temperature was maintained at 35°C with a helium flow of 50 mL/min. An internal standard, deuterated chlorobenzene, was added to every sample prior to sparging.

On each analysis day, a field blank (organic free water) and 2 aqueous composite standards were run along with the samples. The relative retention times and mass spectra of the compounds detected in the wastewater samples were compared with those standards. Quantification by GC/MS was accomplished by measuring the intensity of a specific ion of each component in the sample against that of the prepared standard solution.

QA/QC Procedures

The validity and effectiveness of the method in the analysis of the 38 purgeable organics were monitored through a quality control program. Before performing any analyses, organic-free water samples were spiked with the methanolic standards and analysed using the same procedure described before. Percent recovery of each compound was calculated and is presented in Appendix 3. The reproducibility of the purge and trap GC/MS response was determined by triplicate analysis of the aqueous standards. Detailed reproducibility results are also presented in Appendix 3.

The performance of the analytical method was monitored using deuterated chlorobenzene. This compound was spiked into blank water and analysed many times to obtain the mean value. Then the retention times and area counts of the internal standards, in all the samples and standards run in the same day, were compared to ensure the results were valid. Any sample that did not fall within the control limit was re-analyzed.

Blank water was run each day to check any possible interferences from the analytical system. In addition, the traps were re-fired between samples and the results monitored by the FID to avoid cross contamination.

4.3.1.3 Extractable Organics

Base-neutral extracts of wastewater samples were prepared by serial extraction of one litre of sample with three portions (60 mL) of dichloromethane at pH >11 using a separatory funnel technique. Samples were hand shaken for two minutes after each solvent addition. A stable emulsion always formed after shaking and so each sample was allowed to settle under gravity for ten minutes. The emulsion, which had settled to the bottom of the separatory funnel was run-out into stainless steel centrifuge tubes (250 mL) and separated into organic and aqueous phases by centruging at 10,000 rpm for five minutes. Both phases were poured into a small separatory funnel flask. The aqueous phase remaining in the small separatory funnel was poured back into the bulk of the original sample before extraction with the next portion of solvent. Aliquots (10 mL) of dichloromethane were used to rinse the extract off the drying column and an iso-octane keeper (1-2 mL) was added to the accumulated dried organic extract. The extract was concentrated to 3-5 mL by rotary evaporation and then transferred to a graduated centrifuge tube (10 mL), using a Pasteur pipette and 3 x 1 mL rinses of iso-octane. The extract was then concentrated to a final volume of 5 mL by nitrogen blow-down (ebullation) at 450°C. The centrifuge tube was stoppered, sealed with teflon tape and then refrigerated. The aqueous phase remaining from B/N extraction was adjusted to pH 2 for acidic extraction using the above procedure.

Compounds in the acidic extracts were derivatized to their more volatile methyl ethers and esters using diazomethane to allow for GC analysis of the more polar acidic compounds. In the derivatization, 1 mL of iso-octane and 2 mL of diazomethane/ether solution were added to each 5 mL acidic extract, shaken, and then allowed to stand covered overnight. The derivatized sample was then reduced to 1 mL by nitrogen blowdown to remove excess dichloromethane.

The base/neutral compounds were not derivatized. Approximately 40% of the B/N extracts from both sites contained a light precipitate. Samples with the precipitate were treated ultrasonically for 1 minute to dissolve the sediment and then passed through a solvent-washed filter of silanized glass wool. This procedure dissolved the majority of the precipitates. The glass wool plug was further washed with 1-2 mL of dichloromethane and this procedure dissolved virtually any remaining precipitate. All B/N samples were then reduced to 1 mL volume by nitrogen blowdown.

QA/QC Procedures

All of the samples were spiked at the 50 ppb level with mixture of D10 anthracene, D8 naphthalene, deuterated phenol and deuterated 2-nitrophenol prior to their extraction. D10 anthracene was used to monitor the overall efficiency of the extraction, while the D8 naphthalene indicated the loss of the more volatile components due to concentration steps. Similarily, the deuterated phenols were used as standards for the acidic fraction. The acid fraction required a second 50 ppb spike of D10 anthracene prior to derivitization and concentration (original D10 anthracene separates into B/N fraction).

A standard solution containing approximately 20 ng/ l (equivalent to 20 ppb) of all EPA priority pollutant extractable compounds was prepared and analyzed by GC/MS to determine each compound's fragmentation pattern, relative retention time (RRT) and relative response factor (RRF) compared to the internal standard D10 phenanthrene. The lowest detectable limit of the system was determined by analyzing a series of standard dilutions until the compound of interest could no longer be reliably identified. The RRTs and Method Detection Limits (MDL's) have been summarized in Appendix 3.

In order to determine the percent recoveries for the compounds of interest from the extraction system being used, three standard solutions were spiked into wastewater samples and extracted. The recoveries were then determined by comparison with the original standards. Two of the standard solutions were replicates containing approximately 20 ppb of each of the EPA extractable compounds. The third contained a representative mixture of 25 deutered priority pollutants. The actual percent recovery values used to correct the concentrations of the positive results were from the second spike (% recovery #2) whose values appeared to be in better agreement with the results obtained from the deuterated spikes and those listed in the EPA for wastewater recoveries (EPA Test Method #625). Detailed data from these studies are also presented in Appendix 3.

4.3.1.4 Method Detection Limits - Organics Analyses

Method detection limits (MDL's) (corrected for recoveries) for the organic priority pollutants are presented in Table 5. The method detection limit is defined as the minimum pollutant concentration in the original sample required to provide reproducible quantitative results. Organics concentrations below the MDL, but above the instrument detection limit (IDL - minimum instrumentally detectable concentration in extract or purge sample) were reported as <MDL. The IDL's varied from day to day depending upon instrumental conditions. In general, IDL's were approximately 1/10 of the MDL. Pollutants present in concentrations ranging from zero to 1/10 of the MDL would be reported as not detected (N.D.).

The MDL's from the Arthur D. Little study are also presented in Table 5. Unfortunately, the EPA Treatability Manual did not provide similar data. It is however, assumed that the Little results reasonably reflect the MDL's associated with the EPA data. It is assumed that the IDL's for the Little results are also 1/10 of the MDL's indicated.

TABLE 5. ORGANIC PRIORITY POLLUTANTS METHOD DETECTION LIMITS

COMPOUND	A.D. LITTLE	MANN TESTING
	REPORTING LIMIT µg/l	METHOD DETECTION LIMIT µg/l
Chloromethane	5	3
Dichlorodifluoromethane	5	3
Bromomethane	5	3
Vinyl Chloride	5	3
Chloroethane	5	3
Dichloromethane	1	3
Acrolein	1-7	N.A. (1)
Trichlorofluoromethane	1-6	3
Acrylonitrile	1	N.A.
1,1 Dichloroethylene	1-5	3
1,1 Dichloroethane	1-2	3
1,2 Trichloroethylene	1	3
Chloroform	1	3
1,2 Dichloroethane	1	3
1,1,1 Trichloroethane	1	3
Carbon Tetrachloride	1	3
Bromodichloromethane	1	3
1,2 Dichloropropane	1	3
Trans-1,3 Dichloropropylene	1	3
Trichloroethylene	1-2	3
Benzene	1	2
Cis-1,3 Dichloropropylene	1	3
Dibromochloromethane	1-2	3
1,1,2 Trichloroethane	1	3
Bromoform	1-3	3
1,1,2,2 Tetrachloroethane	1	3
1,1,2,2 Tetrachloroethylene	1	N.A.
Toluene	1	2
Chlorobenzene	1	3
Ethyl Benzene	1	2
2 Chlorophenol	10	3
2 Nitrophenol	10-15	2
Phenol	10	1.6
2,4 Dimethyl Phenol	10	2.5
2,4 Dichlorophenol	10	2.9
2,4,6 Trichlorophenol	10	3.3
4-Chloro-3-Cresol	10	2.0
2,4 Dinitrophenol	20-40	15.0
4,6 Dinitro-2-Cresol	20-40	4.0
Pentachlorophenol	10-25	3.5
4 Nitrophenol	10-25	2.1

TABLE 5 (CONT'D). ORGANIC PRIORITY POLLUTANTS METHOD DETECTION LIMITS

COMPOUND	A.D. LITTLE	MANN TESTING
	REPORTING LIMIT µg/l	METHOD DETECTION LIMIT µg/l
1,3 Dichlorobenzene	10-30 (2)	0.4
1,4 Dichlorobenzene		0.4
1,2 Dichlorobenzene		0.4
Hexachloroethane	10-20	3.0
Bis(Chloromethyl)Ether	-	0.9
Bis(2-Chloroethyl)Ether	10-20	N.A.
Bis(2-Chloroisopropyl)Ether	10	1.0
N-Nitrosodimethylamine	70	N.A.
Nitroso di-n-Propylamine	10-20	0.5
Nitrobenzene	10-20	0.5
Hexachlorobutadiene	10	0.5
1,2,4 Trichlorobenzene	10-20	1.3
2-Chloroethyl Vinyl Ether	-	N.A.
Bis(2-Chloroethoxyl)Methane	10	0.9
Naphthalene	10	0.4
Isophorone	10	0.4
Hexachlorocyclopentadiene	-	10.0
2-Chloronaphthalene	10	0.8
Acenaphthylene	10	0.5
Acenaphthene	10	0.4
Dimethyl Phthalate	10	1.0
2,6 Dinitrotoluene	10	2.0
4 Chlorophenyl Phenyl Ether	10	1.0
Fluorene	10	0.4
2,4 Dinitrotoluene	10	1.5
Diethyl Phthalate	10	5.0
1,2 Diphenylhydrazine	10	0.6
N-Nitrosodiphenylamine	10	0.4
Hexachlorobenzene	10	1.2
4 Bromophenyl Phenyl Ether	10	0.5
Anthracene	5-10	0.3
Phenanthrene		0.3
Di-n-Butyl Phthalate	10	0.4
Fluoranthene	5-10	0.6
Pyrene	5-10	0.5
Benzidine	10-20	10.0
Butyl Benzyl Phthalate	10	0.8
Bis(2-Ethylhexyl)Phthalate	10	6.9
Di-n-Octyl Phthalate		1.5
Chrysene	5-10	0.4
Benzo(a)Anthracene		0.5

TABLE 5 (CONT'D). ORGANIC PRIORITY POLLUTANTS METHOD DETECTION LIMITS

COMPOUND	A.D. LITTLE	MANN TESTING
	REPORTING LIMIT μg/l	METHOD DETECTION LIMIT μg/l
3,3' Dichlorobenzidine	10	0.7
Benzo(b)Fluoranthene	1-5	0.6
Benzo(k)Fluoranthene		0.4
Benzo(a)Pyrene	5-10	0.3
Indeno(1,2,3-c,d)Pyrene	5	1.3
Dibenzo(a,h)Anthracene	5-10	4.0
Benzo(g,h,i)Perylene	5-10	1.5
Alpha-BHC	1	0.7
Gamma-BHC	1	0.7
Heptachlor	1	1.3
Beta-BHC	1	0.5
Delta-BHC	1	1.5
Aldrin	1	1.0
Heptachlor Epoxide	1	0.6
Endosulfan I	1	2.2
DDE	1	0.8
Dieldrin	1	0.5
Endrin	1	1.1
DDD	1	0.6
Endosulfan II		3.0
DDT	1	0.5
Endrin Aldehyde	1	N.A.
Endosulfan Sulfate	1	N.A.
Chlordane	-	1.0
Toxaphene	-	50.0
PCB-1221	-	5.1
PCB-1232	-	5.3
PCB-1242	-	4.5
PCB-1248	-	20.0
PCB-1254	1	23.0
PCB-1260	-	25.0
PCB-1016	-	5.2

Notes: (1) N.A. = Not Analyzed
(2) A.D. Little data reported as Dichlorobenzenes

4.3.2 Metals and Conventional Parameter Analyses

Conventional parameters including BOD_5, COD, suspended solids, nutrients, and total cyanides were submitted daily to the Ministry of the Environment at their Resources Road laboratory in Rexdale for analysis. Metal analyses were conducted by the Ministry using inductively coupled plasma emission spectrophotometric methods and were restricted to the following:

Cadmium
Chromium
Copper
Lead
Mercury
Nickel
Zinc

Standard MOE analysis procedures were employed throughout.

MDL's for the metals and total cyanide for the MOE labs and the A.D. Little study are presented in Table 6.

TABLE 6. METALLIC PRIORITY POLLUTANTS AND TOTAL CYANIDES METHOD DETECTION LIMITS

COMPOUND	A.D. LITTLE	MOE
	REPORTING LIMIT µg/l	METHOD DETECTION LIMIT µg/l
Cadmium	1-3	12-60
Chromium	1-67	32-160
Copper	4-9	24-120
Lead	3-15	200-1000
Manganese	3-11	4-20
Mercury	1-2	(1)
Nickel	1-30	24-120
Zinc	6-50	40-200
Total Cyanides	10-20	5

Note: (1) Sample Specific

5.0 RESULTS AND DISCUSSION

5.1 Catchment Descriptions

5.1.1 York

The York catchment is approximately bounded by Keele Street on the west, the City of North York/City of York boundary on the north, Caledonia Road on the east, and Eglinton Avenue on the south. The catchment, shown in Figure 4, has an estimated total area of 147 ha, with a total residential population of 4,890 based on 1981 census data. The collection system is almost completely combined, and as a result, industrial cooling waters are mixed with process and sanitary wastes.

Land use in this catchment is primarily residential, accounting for over 50% of the total area, as noted in Table 7. The industrial and major commercial establishments are mainly located along Castlefield Avenue. Commercial establishments included retail stores, warehouses, restaurants, gasoline stations, car washes, etc.

TABLE 7. LAND USE IN THE YORK CATCHMENT

LAND USE DESCRIPTION	PERCENTAGE OF CATCHMENT AREA
Low Density Residential; Single Family Dwellings	8.1
Medium Density Residential; Multi-Family Dwellings	46.7
Commercial	11.3
Industrial	29.2
Open Spaced (Parks, Utilities, Railroad right-of-way, etc.)	4.7

In-sewer monitoring was carried out in a manhole at the intersection of Keele St. and Dunraven Ave. The monitoring location is indicated in Figure 4.

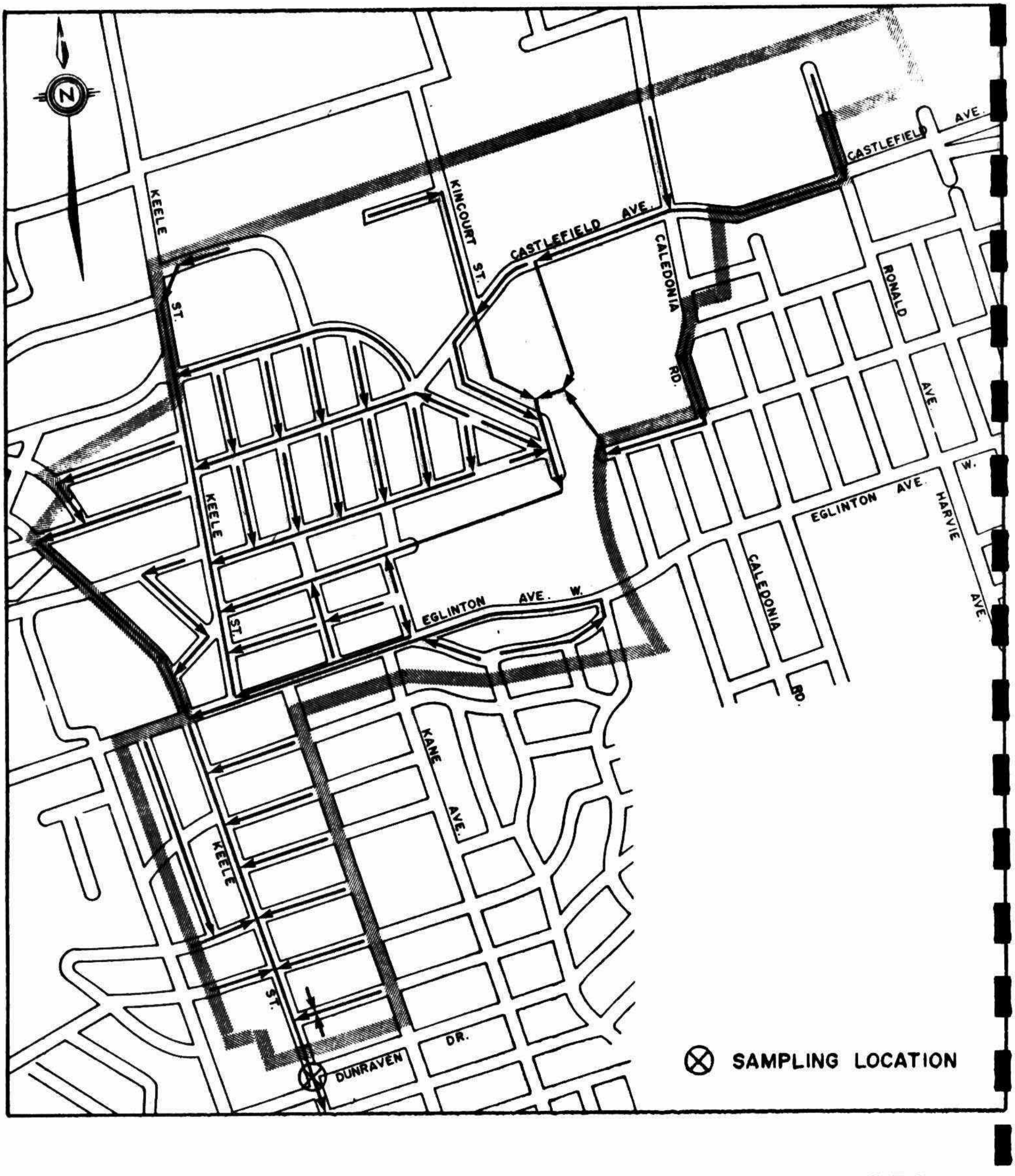


FIGURE 4 — BOUNDARIES OF YORK CATCHMENT AREA

5.1.2 North York

The North York catchment is approximately bounded by Steeles Avenue on the north, Highway 400 on the east, Fenmar Drive on the south and Toryork Drive on the west, as shown in Figure 5. This catchment is completely industrial and commercial in nature, with no residential population. The approximate land use by area is 84% industrial and 16% commercial. The estimated catchment area is 354 ha, and the wastewater collection system is entirely separate.

Monitoring was carried out in a manhole located at the City of North York Works Yard as indicated in Figure 5.

5.2 Wastewater Flow Quantity Estimates

5.2.1 Level I

Wastewater generation was estimated for both catchments from metered water use data. York residential wastewater flows were developed from winter (January - March) per capita water use representing selected residential areas. Data from 1982 and 1983 were employed and the results applied to the catchment as a whole. Industrial and commercial wastewater generation were estimated from 1982 annual water consumption data. Lists of industrial and commercial establishments were compiled for each catchment and the individual water use for each establishment determined from metering records. Water use data were determined for nearly 600 industrial and commercial establishments in the North York catchment. The York catchment contained only 14 industries or major commercial water users. Discrete water use data was determined for each of the fourteen. Wastewater generation for minor commercial water users (e.g. restaurants, stores, etc.) in York could not be estimated because common water metering with residential users made it impossible to separate this commercial component.

Estimates of daily non-residential wastewater generation were based on a 300 day working year for commercial establishments and a 255 day working year for industry. In the Level I procedures, a 100% return factor was assumed for commerce and an 85% return factor was assumed for industry.

In the York catchment, dry weather infiltration was estimated as 227 lcpd. A high DWI is used because of the age of the York system and the relatively high population density (high sewer network density). The North

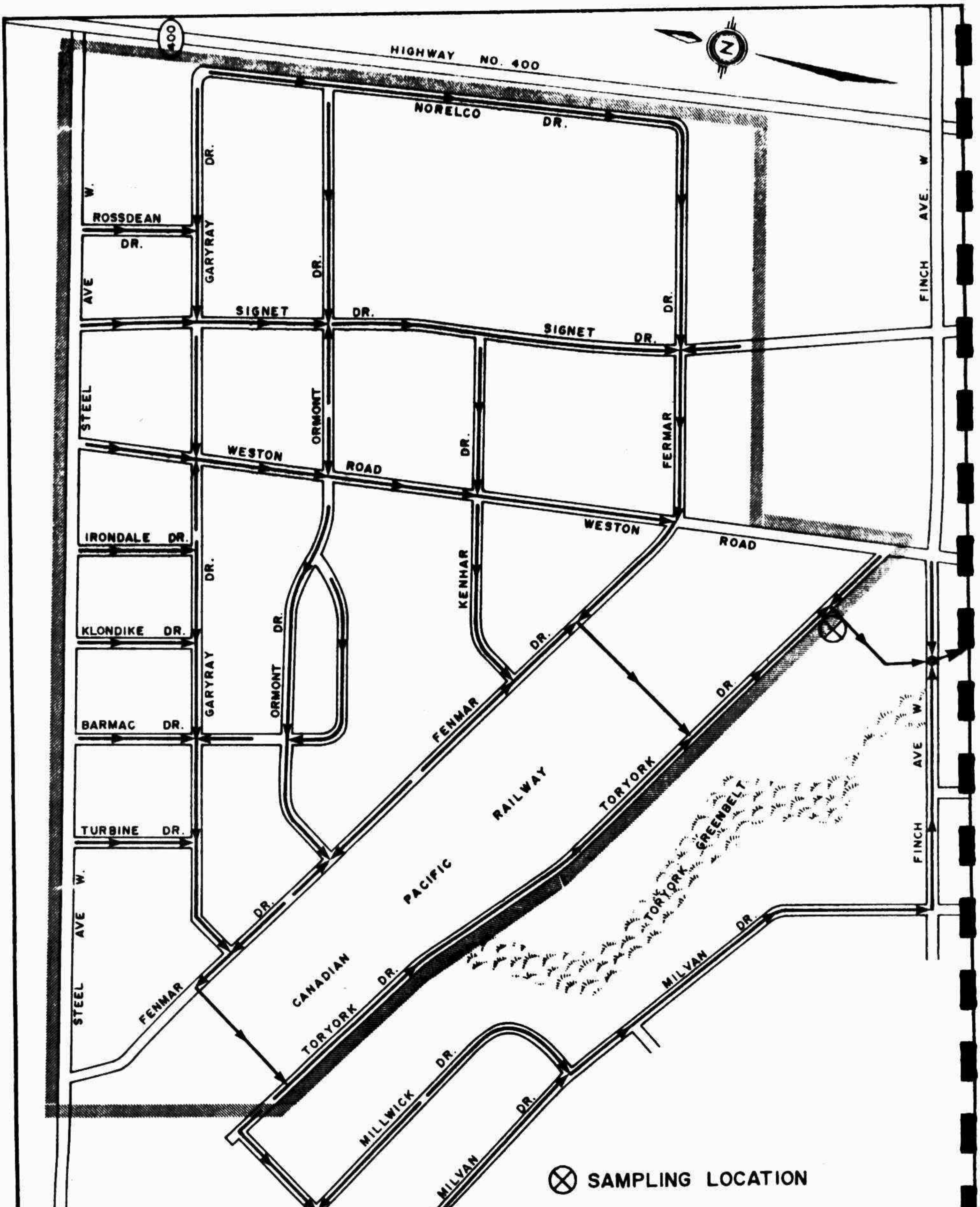


FIGURE 5 — BOUNDARIES OF NORTH YORK CATCHMENT AREA

York sewer system is only approximately 20 years old, and consequently, the infiltration rate was assumed to be considerably less. The basis for estimating dry weather infiltration at North York was 91 lcpd at an assumed equivalent population density of 25 cap/ha. A relatively low population density was assumed (equivalent to approximately 7-8 houses per hectare) in order to approximate the typically lower sewer network densities in industrial areas. Table 8 summarizes the Level I estimates of flow components.

TABLE 8. LEVEL I PREDICTIONS OF WASTEWATER FLOW COMPONENTS

COMPONENT	York (lpd)	North York (lpd)
Residential	909,540 (1)	0
Commercial	48,890	1,757,977
Industrial	427,737 (2)	7,314,924 (2)
Dry Weather Infiltration	1,110,030	805,350
TOTAL	2,496,197	9,878,251

Notes:

(1) Based upon 186 lpcd and a serviced population of 4,890.

(2) 503,220 lpd and 8,605,793 lpd respectively times a return factor of 0.85.

A major difference in the nature of the two catchments is highlighted by the Table 8 data. In York the DWI and residential flows comprise the major flow components, while commercial establishments contribute very little to the total flow. At the North York site, industrial wastewater contributes the greatest flow component to the total. Both commercial and DWI flows are relatively small.

5.2.2 Level II

As previously noted, the same methodology is used to estimate the residential, commercial and DWI components under both Level I and Level II procedures. The refinement in Level II methodology comes in the industrial component. Level II requires knowledge of both the distribution of industrial water useage by SIC group and the fractions of industrial water useage returned to sewerage as process wastewater and as cooling water.

Industrial water useage by SIC group is presented in Tables 9 and 10, respectively for the North York and York catchments.

In North York, 48 industries representing approximately 25% of industrial water usage belong to SIC categories for which individual HC data is available. The remainder of industries have been designated in the "OTHER" category. Although the overall coverage of industries is disappointing, some important SIC groups are represented by distinct HC data. For example, the groups 3471 and 3011-3079 representing electroplaters and the rubber/plastics industry, respectively, each account for about 9% of total water useage. Furthermore, many of the industries in the "OTHER" group are not likely to contribute significant HC inputs (e.g. SIC 2511-12 - furniture manufacture).

In York, 3 of 7 industries accounting for greater than 80% of industrial water usage belong to SIC groups for which individual data is available. A paint manufacturer (SIC 2851) is the largest industrial water user representing nearly 60% of total industrial use.

Estimates for the distribution of industrial water use into its components (i.e. cooling, process and product) were prepared for the larger water users in North York and all industrial water users in York by direct telephone contact. A copy of the questionnaire used to interview industries is presented in Appendix 5. An across-the-board 85% return factor was assumed for all North York industries not interviewed.

Table 11 provides estimates of the distribution of water usage for both catchments. Water use directed to cooling water and incorporated into products represents a significant fraction of the total in both catchments. For example, the 17 industries interviewed in North York together represent about 59% of the total industrial water usage of which greater than 45% (2,324,468 lpd) is not returned to the sanitary sewer.

The Level II industrial wastewater flow for North York is given by equation 3-6 and is expressed as follows:

$$\begin{array}{c}\text{PROCESS WASTEWATER}\\ \text{MAJOR USERS}\end{array} + \begin{array}{c}\text{WATER USAGE}\\ \text{MINOR USERS}\end{array} \times \begin{array}{c}\text{RETURN}\\ \text{FACTOR}\end{array}$$

$$2{,}788{,}885 \quad + \overset{(1)}{(}8{,}605{,}793 - 2{,}788{,}885 - 799{,}628 - 1{,}524{,}840) \times 0.85$$

$$= 5{,}757{,}459 \text{ lpd}$$

(1) Total North York catchment industrial water use.

TABLE 9. NORTH YORK INDUSTRIAL WATER USE SUMMARY

SIC GROUP	NUMBER OF ESTABLISHMENTS	WATER USEAGE (lpd)
2200 - 2299	3	13,533
2821, 2823, 2824	0	0
2834	3	127,051
2841	2	255,380
2844	1	1,753
2851	12	94,690
2893	1	124,024
3011 - 3079	18	754,020
3311	0	0
3112	0	0
3321 - 3325	2	3,212
3431	0	0
3471	5	805,906
3479	1	34,220
Other	273	6,392,004
TOTAL	321	8,605,793

TABLE 10. YORK INDUSTRIAL WATER USE SUMMARY

SIC GROUP	NUMBER OF ESTABLISHMENTS	WATER USEAGE (lpd)
2200 - 2299	0	0
2821, 2823, 2824	1	49,600
2834	0	0
2841	0	0
2844	0	0
2851	1	295,380
2893	0	0
3011 - 3079	1	14,140
3311	0	0
3312	0	0
3321 - 3325	0	0
3431	0	0
3471	0	0
3479	0	0
Other	4	144,100
TOTAL	7	503,220

TABLE 11. DISTRIBUTION OF INDUSTRIAL WATER USE

CATCHMENT	LEVEL II SIC GROUP	INDUSTRIES IN GROUP	PROCESS (1) WASTEWATER	COOLING (1) WATER	(1) PRODUCT
North York	2834	1	105,063		
	2841	2	7,350	7,350	132,240
			5,430	5,430	97,580
	2893	1	124,024		
	3011 - 3079	1	11,069	11,069	
				379,475	
	3471	4	7,188	7,188	
			144,369	389,116	
			109,494		
			95,133		
	Other	8	147,540		836,070
			80,990		458,950
			454,804		
			403,004		
			275,035		
			136,870		
			223,960		
			457,562		
		CATCHMENT TOTAL	2,788,885	799,628	1,524,840
York	2821 - 2825	1		49,600	
	2851	1	10,680	284,700	
	3011	1	14,140		
	Other	4	66,560		
			21,580		
			8,870		
			47,090		
		CATCHMENT TOTAL	168,920	334,300	

Note: (1) All quantities are in units of lpd.

Comparing Level II with Level I predictions for North York shows a reduction of 16% in the estimate of industrial wastewater. The impact of segregating cooling and product waters is equally significant within SIC groups. For example, in the North York SIC 3471, the total wastewater flow is reduced by over 50% through the elimination of cooling water.

Cooling waters in the York catchment are returned to the same combined sewer as process wastewater. Nevertheless, the segregation of the two components is most important for modelling purposes since cooling waters are assumed to contain no HCs. York process wastewater quantities are reduced by 61% between Level I and Level II procedures. In SIC groups 2821 - 2825 and 2851 the reductions in the process wastewaters are 100% and 96%, respectively.

It is evident that Level II procedures give improved accuracy in predicting both total industrial wastewater quantities in the case of separated sanitary systems (segrated cooling waters) and in predicting the industrial process wastewater component where no physical segregation of cooling waters is practised.

5.3 Observed Flow Data and Comparison with Predicted Results

Daily wastewater flows recorded at each of the catchments are summarized in Table 12 and presented graphically in Figures 6 and 7 for the York and North York catchments respectively. Precipitation data are also provided in Table 12. The influence of heavy rainfall events on the combined sewer system of the York area is clearly evident on March 18-19, and again on March 27-28 (Figure 6). The North York system is not subject to such high periodic flows. It is a completely separate system with apparently little infiltration. Flows in North York are relatively constant on week days averaging between 5-7 x 10^6 lpd, with a reduced flow on Saturdays and a very greatly reduced flow on Sundays (Figure 7). In computing average flowrates, all week day flows, irrespective of precipitation, were averaged for the North York catchment. For the York catchment, only week days without rain were used in calculating the average flowrate.

Predicted flowrates for each wastewater component at each level of model application are presented in Table 13. Predicted sewage flows in the York catchment were 16% and 20% higher than the average observed week day dry

TABLE 12. MEASURED FLOW DATA

DATE	DAILY FLOW (5)		PRECIPITATION (1)
	YORK (lpd)	NORTH YORK (lpd)	
March 14 Mon	Incomplete	Incomplete	Tr(2)- Rain
15 Tues	2,506,000	7,955,000	
16 Wed	2,177,000	6,544,000	
17 Thur	1,987,000	6,088,000	
18 Fri	5,149,000 (3)	7,138,000	33.4 mm - Rain
19 Sat	7,949,000	3,786,000	8.9 mm - Rain
20 Sun	2,108,000	1,264,000	1.2 cm - Snow
21 Mon	2,065,000	(4)	13.4 cm - Snow
22 Tues	2,333,000	5,920,600	Tr - Snow
23 Wed	2,203,000	5,823,000	
24 Thur	1,918,000	5,726,000	
25 Fri	2,022,000	6,510,000	
26 Sat	2,523,000	3,261,000	Tr - Snow
27 Sun	4,447,000	1,600,000	4.6 mm Rain + 4.0 cm Snow
28 Mon	Incomplete	Incomplete	1.8 mm Rain + Tr- Snow
Weekday Avg.	2,151,000	6,463,000	

(1) Weather Records from

(2) Tr = Trace

(3) Not used for calculation of weekday average; excessive precipitation

(4) Not used for calculation of weekday average; meter malfunction

(5) Daily Flow = 0000 hr - 2400 hr

TABLE 13. COMPARISON OF OBSERVED AND PREDICTED SANITARY FLOWS

FLOW COMPONENT	YORK		NORTH YORK	
	LEVEL I (lpd)	LEVEL 2 (lpd)	LEVEL I (lpd)	LEVEL II (lpd)
Residential	909,540	909,540	0	0
Commercial	48,890	48,890	1,757,977	1,757,977
Industrial - Process/Sanitary	427,737	168,920	7,314,924	5,757,459
- Cooling		334,300		0
Dry Weather Infiltration	1,110,030	1,110,030	805,350	805,350
Total Predicted Flows	2,496,197	2,571,680	9,878,251	8,320,786
Observed Week Day Average Sanitary Flow	2,151,000		6,463,000	

FIGURE 6. AVERAGE DAILY FLOW RATES IN YORK CATCHMENT (KEELE AND DUNRAVEN)

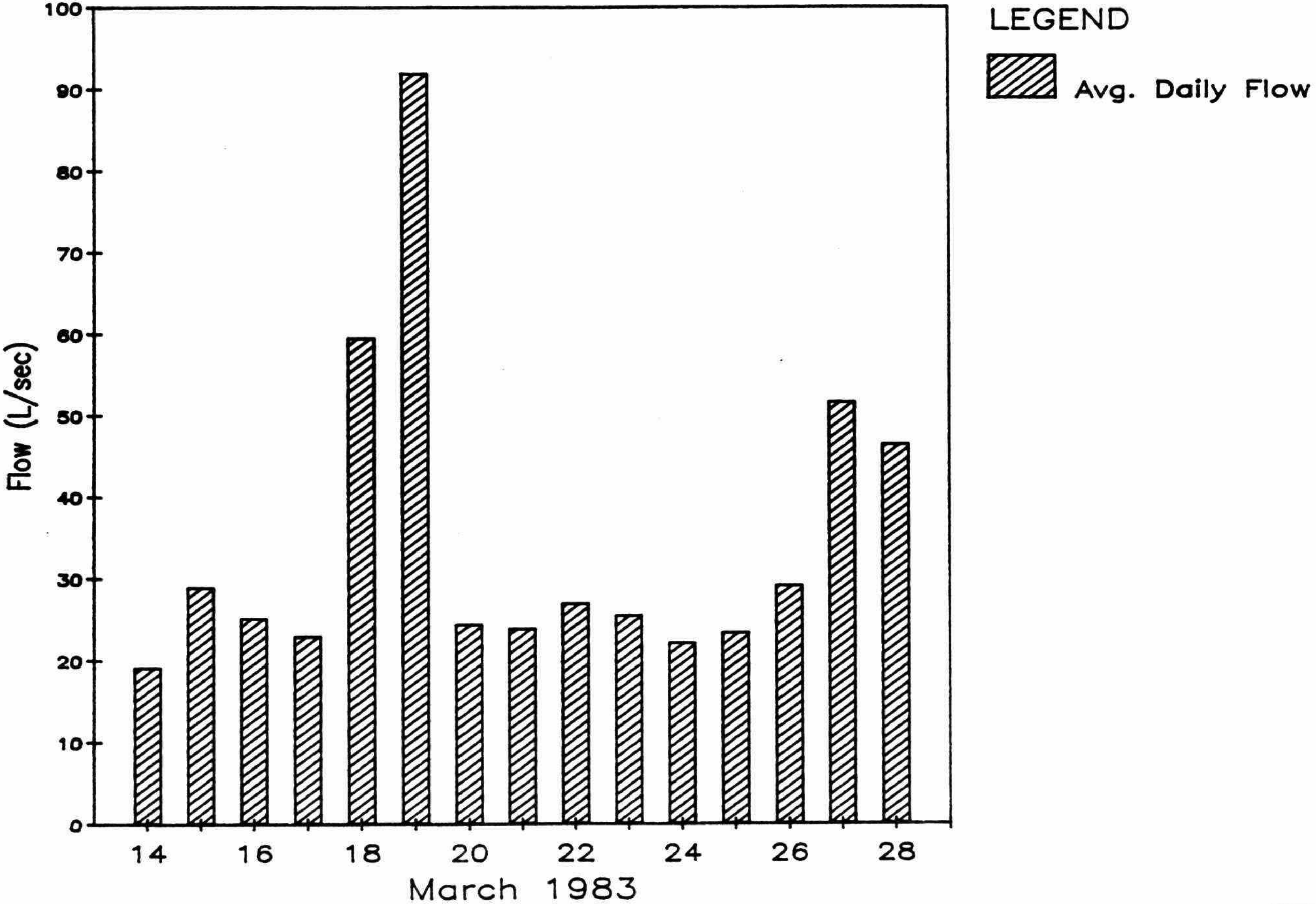
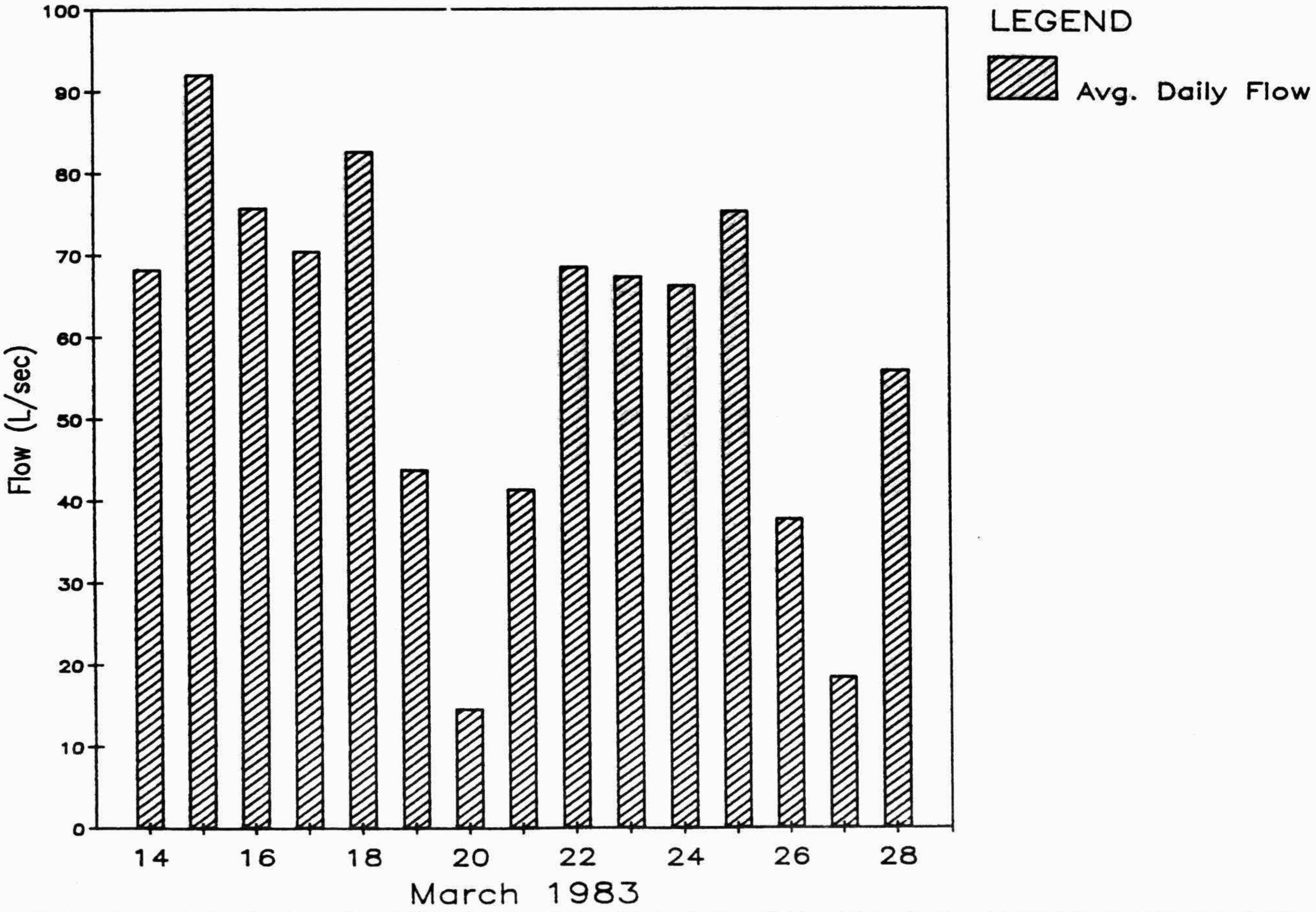


FIGURE 7. AVERAGE DAILY FLOW RATES IN NORTH YORK CATCHMENT (WORKS YARD)



weather flow for Level I and Level II of model application, respectively. In the York case since both cooling and process waters are returned to a common sewer and since no industries incorporate significant quantities of water into their products, the refinements of the Level II methodology yielded little difference. For other catchments where substantial water is used in products (e.g. bottling, canning), the Level II methodology would have provided superior results.

For the North York catchment, the Level I flow predictions were 53% higher than observed average week day flows. Level II estimates reduced the disparity to 29% in excess of observed results. The advantage of the Level II procedures are clearly highlighted in this case. Overall, Level II estimates and observed flows were remarkably consistent. Level I procedures although yielding good agreement in the York cannot be relied upon to produce consistent estimates where cooling waters are segregated.

5.4 **Wastewater Characteristics - Conventional Parameters**

Conventional wastewater characteristics for each study day are presented in Tables 14 and 15 for the York and North York catchments respectively. Average characteristics are reported in Table 16 for both catchments. From the standpoint of lumped parameters (e.g. BOD_5, COD), the wastewaters were of high strength in both catchments, reflecting industrial contributions. Wastewater characteristics were also quite variable. For example, at the North York site daily COD values ranged from 400 to 2400 mg/l. Weekend quality was not much different from week day quality for any of the parameters at either catchment. The substantial rainfall of March 18 and 19 is reflected in the March 19 York results which show significant dilution. No such effect is observed in the North York catchment confirming that the sewerage is relatively free from inflow or wet weather infiltration.

5.5 **Wastewater Characteristics - Hazardous Contaminants**

A total of 20 purgeable compounds and 16 extractable compounds (7 Acid and 9 Base-Neutral) were observed in any sample from either site. Neither pesticides nor PCBs were found in detectable quantities (below IDL) in

TABLE 14. DAILY WASTEWATER CHARACTERISTICS - YORK CATCHMENT

PARAMETER	DAY DATE SAMPLE	WASTEWATER CONSTITUENT CONCENTRATION (mg/l) (1)												
		Th Mar 17 G (2)	F Mar 18 G	S Mar 19 G	S Mar 20 -	M Mar 21 G	T Mar 22 -	W Mar 23 C	Th Mar 24 C	F Mar 25 C	S Mar 26 C	S Mar 27 C	M Mar 28 C	T Mar 29 C
BOD_5		450	325	42	-	182	-	369	200	-	329	375	200	280
COD		1130	422	112	-	396	-	822	496	1060	1540	2740	810	1030
TSS		193	155	63	-	131	-	180	100	101	120	264	138	97
VSS		136	120	36	-	89	-	122	63	75	90	185	63	73
pH		8.1	8.0	8.0	-	8.1	-	8.9	7.9	7.9	7.8	7.5	7.9	8.0
Total P		5.8	4.9	1.0	-	3.6	-	3.6	2.7	2.8	3.0	3.4	1.5	2.1
Filt NH_3-N		8.6	13.8	2.6	-	18.4	-	8.1	13.5	13.9	14.5	6.8	5.5	3.2

(1) except pH
(2) grab (G) or 24 hr composite (C) sample

TABLE 15. DAILY WASTEWATER CHARACTERISTICS - NORTH YORK CATCHMENT

PARAMETER	DAY DATE SAMPLE	WASTEWATER CONSTITUENT CONCENTRATION (mg/l) (1)												
		Th Mar 17 C (2)	F Mar 18 G	S Mar 19 G	S Mar 20 -	M Mar 21 G	T Mar 22 C	W Mar 23 C	Th Mar 24 C	F Mar 25 C	S Mar 26 C	S Mar 27 C	M Mar 28 C	T Mar 29 C
BOD_5		355	385	329	-	615	243	990	770	200	219	504	69	292
COD		574	634	656	-	1090	676	2400	1360	786	1120	810	400	984
TSS		204	223	279	-	262	221	251	146	99	312	411	60	258
VSS		116	139	124	-	154	116	169	93	62	170	99	41	126
pH		7.9	8.9	7.9	-	8.1	7.9	10.3	9.3	8.0	7.0	8.2	8.6	8.2
Total P		7.6	6.2	3.0	-	6.2	8.7	12.0	3.3	2.6	10.4	4.2	1.0	9.4
Filt NH_3-N		3.6	2.4	<0.1	-	<0.1	7.7	3.4	1.7	1.2	3.5	0.6	9.4	2.5

(1) except pH
(2) 24 hr composite (C) or grab (G) sample

TABLE 16. AVERAGE WASTEWATER CHARACTERISTICS - YORK AND NORTH YORK CATCHMENTS

PARAMETER	WEEKDAY CONCENTRATIONS (1) IN					
	YORK			NORTH YORK		
	n	A.Mean(2)	S.D.	n	A.Mean(2)	S.D.
BOD_5	4	295 (2)	73	7	438	312
COD	5	990	380	7	1130	622
TSS	5	120	35	7	213	72
VSS	5	85	23	7	122	39
pH	5	8.1	0.5	7	8.4	1.1
Total P	5	2.8	0.5	7	7.7	3.6
Filt. NH_3-N	5	10.6	4.9	7	3.4	2.1

(1) concentrations in weekday composite samples
(2) all values mg/l except pH

any sample. The selected seven metals and total cyanides were also observed at both sites. Table 17 presents the list of compounds identified and their frequency of detection. Any compound detected less than a total of 4 times (<18%) at a given site was not subsequently used for comparison with predicted results.

Although, the xylenes, styrene, carbon disulfide and diethyl ether were observed in detectable quantities in this study, they were not assessed in the A.D. Little study or the Treatability Manual because they are not EPA priority pollutants. The data is included for the sake of completeness.

Dichloromethane, ethyl benzene and toluene from the purgeable group were detected in all the samples. Both chloroform and benzene also had very high detection frequency. In the acid extractable group, only two compounds, phenol and 2,4-dimethyl phenol, were detected with any regularity. In contrast, a significant number of the base-neutral extractables, particularly the phthalates, dichlorobenzenes and selected PAHs (naphthalene, phenanthrene), were quite often detected in both catchments. The group of selected metals and total cyanides are not presented in Table 17 since they were detected in every sample.

Concentrations of organic and metallic hazardous contaminants measured in samples from each day of the study are reported in Tables 18 and 19 for York and North York, respectively. All organics data presented are recovery corrected. Raw GC/MS data are presented in the Mann Testing report (8).

Observed levels of purgeables were determined from week day grab samples collected on the date of submittal. Concentrations of other parameters, including extractable organics, metals and conventional parameters were determined from week day composite samples that were submitted on the morning following collection (e.g. the composite sample submitted on Saturday March 26, was actually collected from March 25 a.m. to March 26 a.m., and thus included the industrial and commercial activity of the Friday). Mean values were calculated using finite observed concentrations. A concentration equal to the detection limit was used where data are reported as detected but below the MDL and a zero value was used if the HC was not detected (below IDL).

High concentrations of specific purgeable organics were noted in the wastewaters of both catchments. Extractable compounds tended to be present in lower concentrations. North York wastewater tended, in general, to

TABLE 17. FREQUENCY OF DETECTION OF ORGANIC COMPOUNDS

POLLUTANT GROUP/NAME	NUMBER OF TIMES DETECTED		PERCENTAGE FREQUENCY OF DETECTION
	YORK (1)	NORTH YORK (2)	
PURGEABLE			
Benzene	11	9	91
Bromodichloromethane	ND	1	5
Bromomethane	2	ND	10
Carbon Tetrachloride	ND	1	5
Chloroform	10	11	95
Dibromochloromethane	ND	1	5
1,1 Dichloroethylene	2	11	59
Dichloromethane	11	11	100
Ethyl Benzene	11	11	100
Tetrachloroethylene	6	8	64
Toluene	11	11	100
1,1,1, Trichloroethane	3	11	64
Trichloroethylene	2	10	55
Trichloroflurormethane	1	ND	5
*Carbon Disulfide	1	1	18
*Ethyl Ether	1	4	23
*m-Xylene	11	11	100
*o-Xylene	11	11	100
*p-Xylene	11	11	100
*Styrene	11	9	91
EXTRACTABLE - ACID			
p-Chloro-m-Cresol	ND	1	5
2 Chlorophenol	ND	1	5
2,4 Dichlorophenol	ND	2	10
2,4 Dimethyl Phenol	6	8	70
Phenol	6	6	60
2,4,6 Trichlorophenol	ND	1	5
*Silvex	1	ND	5
EXTRACTABLE BASE-NEUTRAL			
Acenapthalene	ND	1	5
Butyl Benzyl Phthalate	8	3	55
Di-n-Butyl Phthalate	8	6	70
1,2 Dichlorobenzene	3	7	50
1,4 Dichlorobenzene	9	9	90
Bis(2-Ethyl-Hexyl) Phthalate	9	6	75
Napthalene	9	9	96
Di-n-Octyl Phthalate	7	0	35
Phenanthrene	6	6	60

Notes:
* Not EPA Priority Pollutant
(1) Total Number of York Samples = 11
(2) Total Number of North York Samples = 11

TABLE 18. OBSERVED HAZARDOUS CONTAMINANT CONCENTRATIONS - NORTH YORK CATCHMENT

POLLUTANT GROUP/NAME	Th Mar 17 G	F Mar 18 G	S Mar 19 G	M Mar 21 G	T Mar 22 -	W Mar 23 C	Th Mar 24 C	F Mar 25 C	S Mar 26 C	S Mar 27 C	M Mar 28 C	T Mar 29 C	AVERAGE CONC'N
Purgeable													
Benzene	<2.0	6.7	<2.0	ND	<2.0	-	<2.0	4.2	<2.0	ND	3.0	<2.0	2.4
Chloroform	21	136	9.8	43	13	-	187	13	8.4	5.4	11	71	47
1,1 Dichloroethylene	10	7.7	1.3	2.8	27	-	3.8	7.0	<3.0	<3.0	111	14	17
Dichloromethane	180	676	56	209	923	-	9.3	34	21	5.4	129	38	207
Ethyl Benzene	154	546	12	13	132	-	2.8	9.4	4.5	1.4	17	11	82
Tetrachloroethylene	ND	90	ND	1.6	32	-	5.0	<3.0	3.1	ND	<3.0	<3.0	13
Toluene	12	2258	41	79	190	-	32	358	5.9	3.3	335	1603	447
1,1,1 Trichloroethane	158	106	16	32	314	-	17	47	8.4	4.2	941	61	155
Trichloroethylene	19	ND	5.9	39	6.5	-	64	15	4.0	3.5	802	6.3	83
Non-Priority Pollutants													
Ethyl Ether	ND	3.1	ND	ND	3.1	-	ND	3.0	ND	ND	<3.0	ND	<3.0
m-Xylene	170	343	12	29	184	-	12	33	21	5.5	43	25	80
O-Xylene	116	671	28	19	204	-	16	19	12	<2.0	26	17	103
p-Xylene	157	574	17	15	111	-	7.7	11	7.7	2.4	17	11	8.5
Styrene	5.0	1.5	ND	0.4	ND	-	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
Extractable - Acid													
2,4 Dimethyl Phenol	102	2.4	5.1	-	8.4	5.4	5.6	2.9	6.8	ND	ND	ND	13
Phenol	27	17	ND	-	30	ND	1.4	2.2	12	ND	ND	ND	8.2

Notes: (1) ND = Not Detected
(2) - = Not Sampled

TABLE 18 (CONT'D). OBSERVED HAZARDOUS CONTAMINANT CONCENTRATIONS - NORTH YORK CATCHMENT

POLLUTANT GROUP/NAME	Th Mar 17 G	F Mar 18 G	S Mar 19 G	M Mar 21 G	T Mar 22 -	W Mar 23 C	Th Mar 24 C	F Mar 25 C	S Mar 26 C	S Mar 27 C	M Mar 28 C	T Mar 29 C	AVERAGE CONC'N
Extractable-Base-Neutral													
Bis(2-Ethyl-Hexyl) Phthalate	31	29	6.8	-	25	ND	ND	ND	0.4	ND	7.4	ND	9.1
Butyl Benzyl Phthalate	1.5	1.4	ND	-	ND	ND	ND	ND	6.8	ND	6.8	ND	0.9
Di-n-Butyl Phthalate	50	61	11	-	ND	30	22	ND	ND	ND	ND	62	22
1,2 Dichlorobenzene	5.1	16	ND	-	16	2.5	ND	0.4	3.0	3.6	ND	1.7	4.4
1,4 Dichlorobenzene	2.1	3.7	0.8	-	3.7	2.6	6.1	ND	2.2	2.3	1.1	1.7	2.4
Napthalene	6.6	5.6	2.5	-	5.6	3.1	ND	4.6	5.5	1.6	57	3.8	8.7
Phenanthrene	1.3	ND	ND		1.0	1.2	0.7	ND	1.6	0.6	ND	ND	0.6
Metals and Cyanide													
Cadmium	2	270	750	15000	180	-	240	250	550	300	20	260	1620
Chromium	490	1200	2100	1600	2600	-	1600	1500	16000	1500	90	2500	2844
Copper	230	130	170	480	370	-	170	70	480	160	90	160	228
Lead	1300	20	40	40	60	-	50	10	100	20	10	30	153
Mercury	0.9	0.3	0.1	0.4	0.3	0.7	0.2	0.08	0.4	0.1	0.05	-	0.32
Nickel	20	260	4300	1200	580	-	280	70	1500	510	90	170	598
Zinc	1100	5300	10300	15000	6900	-	5000	7500	10000	3600	1500	18000	7655
Total CN^-	33	420	800	4050	1700	3600	3200	3000	3800	1200	1600	9400	2982

Note: All concentration units expressed as ug/L.

TABLE 19. OBSERVED HAZARDOUS CONTAMINANT CONCENTRATIONS - YORK CATCHMENT

POLLUTANT GROUP/NAME	Th Mar 17 G	F Mar 18 G	S Mar 19 -	S Mar 20 -	M Mar 21 -	T Mar 22 -	W Mar 23 C	Th Mar 24 C	F Mar 25 C	S Mar 26 C	S Mar 27 C	M Mar 28 C	T Mar 29 C	AVG CONC'N	AVG EXC. Mar 17
Purgeable															
Benzene	42.1	<2.0	<2.0	-	<2.0	-	<2.0	2.1	3.4	2.2	<2.0	2.8	<2.0	6.4	2.3
Chloroform	ND	20.5	3.1	-	4.2	-	3.0	3.0	18	10	7.9	3.8	5.1	7.1	7.1
Dichloromethane	8910	146	246	-	90	-	576	97	1193	17	76	155	43	1050	264
Ethyl Benzene	4586	296	82	-	30	-	314	232	225	6.0	19	121	4.0	521	398
Tetrachloroethylene	127	ND	ND	-	ND	-	ND	ND	ND	ND	ND	5.4	<3.0	12	<3.0
Toluene	3676	163	542	-	17	-	90	39	122	2	29	183	12	443	120
1,1,1 Trichloroethane	18	ND	ND	-	ND	-	3.5	<3.0	ND	ND	ND	ND	ND	<3.0	<3.0
Non-Priority Pollutants															
m-Xylene	5386	249	62	-	69	-	471	405	723	17	50	373	36	713	246
O-Xylene	2252	121	63	-	11	-	87	78	96	2.7	9.5	74	10	255	65
p-Xylene	3095	286	95	-	24	-	253	228	234	5.5	18	156	15	401	132
Styrene	99	16	10	-	3.2	-	59	29	22	<3.0	<3.0	<3.0	<3.0	22	14
Extractable - Acid															
2,4 Dimethyl Phenol	ND	3.0	-	-	-	-	11	0.8	ND	2.4	2.8	0.5	ND	<2.5	<2.5
Phenol	2.0	1.0	-	-	-	-	ND	0.6	0.4	1.1	2.0	ND	ND	<1.6	<1.6

Notes:
(1) ND = Not Detected
(2) - = Not Sampled

TABLE 19 (CONT'D). OBSERVED HAZARDOUS CONTAMINANT CONCENTRATIONS - YORK CATCHMENT

POLLUTANT GROUP/NAME	Th Mar 17 G	F Mar 18 G	S Mar 19 G	S Mar 20 G	M Mar 21 -	T Mar 22 C	W Mar 23 C	Th Mar 24 C	F Mar 25 C	S Mar 26 C	S Mar 27 C	M Mar 28 C	T Mar 29 C	AVG CONC'N	AVG EXC. Mar 17
Extractable-Base-Neutral															
Bis(2-Ethyl-Hexyl) Pthalate	6.3	2.3	-	-	-	-	25	10	9.4	0.3	23	55	20	25	21
Butyl Benzyl Pthalate	ND	11	-	-	-	-	13	4.1	6.3	3.1	3.6	4.5	17	7.0	7.9
Di-n-Butyl Phthalate	ND	8.1	-	-	-	-	8.3	5.5	7.4	4.5	4.5	6.0	6.8	5.7	6.4
Di-n-Octyl Phthalate	2.5	1.3	-	-	-	-	ND	0.5	0.5	0.5	1.0	ND	0.5	<1.5	<1.5
1,2 Dichlorobenzene	ND	ND	-	-	-	-	ND	8.1	8.1	ND	ND	ND	ND	2.7	3.0
1,4 Dichlorobenzene	1.9	0.3	-	-	-	-	0.3	2.0	0.2	0.6	4.6	0.6	0.9	1.3	1.2
Napthalene	28	2.2	-	-	-	-	1.8	2.7	0.7	2.3	3.3	2.2	6.4	5.5	2.7
Phenanthrene	ND	5.7	-	-	-	-	0.7	ND	0.4	ND	1.9	1.9	ND	1.2	1.4
Metals and Cyanide															
Cadmium	249	<4.0	<4.0	-	20	-	-	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	30	5.8
Chromium	2200	40	30	-	30	-	-	50	30	70	50	70	50	262	47
Copper	140	90	70	-	100	-	-	200	110	100	160	130	100	126	118
Lead	200	50	50	-	90	-	-	120	120	80	200	190	190	129	121
Mercury	1.6	0.3	0.1	-	0.2	-	0.5	0.09	0.3	0.2	0.2	0.3	-	0.40	0.24
Nickel	160	10	30	-	10	-	-	10	10	10	10	10	10	27	12
Zinc	4400	170	180	-	210	-	-	210	180	170	410	230	260	642	224
Total CN$^-$	950	10	5.0	-	40	-	7.0	7.0	<3.0	8.0	7.0	14	9.0	106	12

Note: All concentration units expressed as ug/L.

exhibit higher concentrations of HCs. Metallic contaminants in particular were present at higher levels in North York. The high levels of zinc, chromium, cyanide and cadmium were typical of electroplating industries.

Non-priority pollutants such as xylenes were present at significant levels in North York wastewater. Qualitative identification of non-priority pollutants revealed that wastewater from both catchments had elevated hydrocarbon background levels consisting of both branched and long chain alaphatic and polyalkyl-substituted aromatic hydrocarbons.

The March 17 York sample had particularly high concentrations of all HCs at levels not observed in any other sample. Since this one result tended to skew the average, average concentrations were calculated with and without the March 17 values included. In most instances the exclusion of the March 17 data resulted in significant reductions in average values, in some cases by as much as an order of magnitude (e.g. dichloromethane).

It was subsequently decided to use the average without March 17 data for further analysis.

5.6 Comparison of Observed and Predicted HC Concentrations and Loadings

Three levels of comparison were carried out between observed and predicted results. The listings of observed and predicted HCs were compared first to assess the number of compounds or metals predicted but not detected (below IDL) and the number of compounds detected but not predicted. The second and third measures of prediction accuracy were quantitative and included comparison of observed and predicted concentrations and daily sewage loadings at the catchment outlet. All comparisons were restricted to compounds or metals for which analyses were carried out and to compounds or metals included in the EPA's priority pollutant list.

Evaluations were carried out for a composite list of HCs which included all those compounds or metals in the above categories predicted or observed or both. The following rules were employed for the quantitative comparisons:

1) Predictive accuracy was assessed by computing the log of the ratio of observed/predicted concentrations. If the log ratio fell between ± 0.5 the predicted result was said to be within 1/2 log of the observed. Similarly, if the log ratio fell between ± 1.0 the predicted result was said to be within 1 log of the observed.

2) If the predicted HC concentration was less than the MDL reported by A.D. Little, but greater than 1/10 of the MDL (assumed IDL) the predicted value was assumed equal to the MDL and compared with the observed result.
3) If an observed result fell between the IDL and MDL reported by Mann Testing, the result was assumed equal to the Mann Testing MDL and compared with the predicted result(s).
4) If an observed or predicted result was below the IDL (A.D. Little for predicted result, Mann Testing for observed) the result was presented in parentheses, and any comparison was carried out using the IDL value.
5) The observed average concentrations presented for York were based on average values calculated excluding March 17 results.
6) The observed loadings were calculated upon the basis of the observed dry weather average weekday sewage flowrates. The predicted loadings for each level of model application were calculated with the predicted flowrate appropriate to that level of application.

Tables 20 and 21 present the comparison of predicted and observed HC concentrations for the York and North York catchments, respectively. A total of 30 contaminants were predicted by either level of model application for the York catchment, while 36 were predicted for North York. In contrast, 24 EPA priority pollutants were observed in York, while 25 were observed in North York.

Table 22 presents the breakdown by HC category of predicted but not detected and detected but not predicted contaminants for both catchments at both levels of model application. The number of compounds, which were predicted but not observed far outweighs those detected but not predicted in both catchments. York results show a slight improvement between Levels I and II in the total number predicted but not detected. North York results show the opposite trend. In this case, the Level II model predicted the incidence of a greater number of compounds than Level I. The number of compounds detected but not predicted is approximately the same for both catchments, and at both levels of model application. More detailed examination of Table 21 reveals that in all cases the preponderance of predicted compounds having no observed analog were in the purgeable group. For example, in North York 78%

TABLE 20. COMPARISON OF OBSERVED AND PREDICTED HC CONCENTRATIONS - YORK CATCHMENT

PRIORITY POLLUTANT GROUP/POLLUTANT	AVERAGE OBSERVED CONC,N (μg/l)	LEVEL I			LEVEL II		
		PREDICTED CONC'N (μg/l)	1/2 LOG	1 LOG	PREDICTED CONC'N (μg/l)	1/2 LOG	1 LOG
Purgeable							
Benzene	2.3	<1.0	YES	YES	5.4	YES	YES
Bromodichloromethane	(<0.3)	<1.0	NO	YES	<1.0	NO	YES
Carbon Tetrachloride	(<0.3)	5.1	NO	NO	2.2	NO	YES
Chlorobenzene	(<0.3)	<1.0	NO	YES	(<0.1)	YES	YES
Chloroethane	(<0.3)	(<0.5)	YES	YES	13.8	NO	NO
Chloroform	7.1	3.4	YES	YES	2.3	YES	YES
1,1 Dichloroethane	(<0.3)	<1.5	NO	YES	(<0.15)	YES	YES
1,2 Dichloroethane	(<0.3)	<1.0	NO	YES	<1.0	NO	YES
1,2-t Dichloroethylene	(<0.3)	2.1	NO	YES	<1.0	NO	YES
Dichloromethane	264	(<0.15)	NO	NO	3.5	NO	NO
Ethyl Benzene	398	18.4	NO	NO	9.2	NO	NO
Tetrachloroethylene	<3.0	15.3	NO	YES	6.4	YES	YES
Toluene	120	10.6	NO	YES	14.2	NO	YES
1,1,1 Trichloroethane	<3.0	16.3	NO	YES	4.5	YES	YES
Trichloroethylene	(<0.3)	5.0	NO	NO	1.6	NO	YES
Extractable-Acid							
2,4 Dimethyl Phenol	<2.5	13.6	NO	YES	<10	NO	YES
Pentachlorophenol	(<0.35)	<17.5	NO	NO	<17.5	NO	NO
Phenol	<1.6	26.7	NO	NO	<10	NO	YES
Extractable-Base-Neutral							
Bis(2-Ethyl-Hexyl) Phthalate	21	10.4	YES	YES	<1.0	YES	YES
Butyl Benzyl Phthalate	7.9	33.1	NO	YES	<1.0	YES	YES
Di-n-Butyl Phthalate	6.4	15.6	YES	YES	<1.0	YES	YES
Dichlorobenzene (1)	4.2	69	NO	NO	15.7	NO	YES
Diethyl Phthalate	(<0.5)	<10.0	NO	NO	<10.0	NO	NO
Di-n-Octyl Phthalate	<1.5	(<1.0)	YES	YES	(<1.0)	YES	YES
Napthalene	2.7	10.0	NO	YES	<10	NO	YES
Phenanthrene	1.4	(<0.75)	YES	YES	(<0.75)	YES	YES
Metals and CN^-							
Cadmium	5.8	4.4	YES	YES	2.4	YES	YES
Chromium	47	136	YES	YES	37	YES	YES
Copper	118	50	YES	YES	35	NO	YES
Lead	121	9.5	YES	YES	54	YES	YES
Mercury	0.24	<1.5	NO	YES	4.9	NO	NO
Nickel	1.2	21	YES	YES	<15.5	YES	YES
Zinc	224	23.5	YES	YES	179	YES	YES
Total CN^-	12	16.8	YES	YES	<15	YES	YES

Note: (1) Observed isomer concentrations have been summed to give total dichlorobenzene.

TABLE 21. COMPARISON OF OBSERVED AND PREDICTED HC CONCENTRATIONS - NORTH YORK CATCHMENT

PRIORITY POLLUTANT GROUP/POLLUTANT	AVERAGE OBSERVED CONC'N (μg/l)	LEVEL I			LEVEL II		
		PREDICTED CONC'N (μg/l)	1/2 LOG	1 LOG	PREDICTED CONC'N (μg/l)	1/2 LOG	1 LOG
Purgeable							
Benzene	2.4	1.4	YES	YES	25	NO	YES
Bromodichloromethane	(<0.3)	1.4	NO	YES	1.4	NO	YES
Carbon Tetrachloride	(<0.3)	21.1	NO	NO	22.8	NO	NO
Chlorobenzene	(<0.3)	<1.0	NO	YES	<1.0	NO	YES
Chloroethane	(<0.3)	(<0.5)	YES	YES	72	NO	NO
Chloroform	47	10.0	NO	YES	52	YES	YES
Dibromochloromethane	(<0.3)	<1.5	NO	YES	1.5	NO	YES
1,1 Dichloroethane	(<0.3)	1.2	NO	YES	1.4	NO	YES
1,2 Dichloroethane	(<0.3)	<1.0	NO	YES	3.6	NO	NO
1,1 Dichloroethylene	17	8.6	YES	YES	7.0	YES	YES
1,2-t Dichloroethylene	(<0.3)	8.9	NO	NO	7.2	NO	NO
Dichloromethane	207	(<0.1)	NO	NO	57	NO	YES
Dichloropropane	(<0.3)	(<0.1)	YES	YES	<1.0	NO	YES
Ethyl Benzene	82	75	YES	YES	152	YES	YES
Tetrachloroethylene	13	56	NO	YES	49	NO	YES
Toluene	447	41	NO	NO	66	NO	YES
1,1,1 Trichloroethane	15.5	64	YES	YES	58	YES	YES
1,1,2 Trichloroethane	(<0.3)	(<0.1)	YES	YES	<1.0	NO	YES
Trichloroethylene	83	21	NO	YES	36	YES	YES
Extractable-Acid							
2,4 Dimethyl Phenol	13	55	NO	YES	42	NO	YES
Pentachlorophenol	(<0.35)	8.5	NO	NO	28	NO	NO
Phenol	8.2	10.1	NO	NO	84	NO	YES
Extractable-Base-Neutral							
Bis(2-Ethyl-Hexyl) Phthalate	9.1	33	NO	YES	36	NO	YES
Butyl Benzyl Phthalate	0.9	127	NO	NO	98	NO	NO
Di-n-Butyl Phthalate	22	52	YES	YES	43	YES	YES
Dichlorobenzene (1)	6.8	280	NO	NO	214	NO	NO
Diethyl Phthalate	(<0.5)	<10.0	NO	NO	(<2.0)	YES	YES
Isophrone	(<0.04)	(<1.0)	YES	YES	664	NO	NO
Napthalene	8.7	38	NO	YES	30	NO	YES
Phenanthrene	0.6	(<0.15)	YES	YES	(0.75)	YES	YES
Metals and CN^-							
Cadmium	1620	15.4	NO	NO	36	NO	NO
Chromium	2844	538	NO	YES	1084	YES	YES
Copper	228	102	YES	YES	249	YES	YES
Lead	153	249	YES	YES	1163	NO	YES
Mercury	0.32	1.5	NO	YES	12.3	NO	NO
Nickel	49.8	83	NO	YES	442	YES	YES
Zinc	7655	662	NO	NO	1040	NO	YES
Total CN^-	2982	67	NO	NO	104	NO	NO

Note: (1) Observed isomer concentrations have been summed to give total dichlorobenzene.

TABLE 22. COMPARISON OF THE INCIDENCE OF OBSERVED AND PREDICTED HAZARDOUS CONTAMINANTS

CATCHMENT	MODEL LEVEL	PURGEABLE		EXTRACTABLE ACID		EXTRACTABLE BASE-NEUTRAL		METALS AND CN⁻		TOTAL	
		PRED/ NOT DET	DET/ NOT PRED	PRED/ NOT DET	DET/ NOT PRED	PRED/ NOT DET	DET/ NOT PRED	PRED/ NOT DET	DET/ NOT PRED	PRED/ NOT DET	DET/ NOT PRED
York	Level I	8	1	1	0	1	2	0	0	10	3
	Level II	6	0	1	0	1	2	0	0	8	2
North York	Level I	7	1	1	0	1	1	0	0	9	2
	Level II	10	0	1	0	1	1	0	0	12	1

of the compounds not observed but predicted by the Level I Model were in the purgeable group, while 83% of the compounds not observed but predicted by the Level II Model were purgeables. In most cases, the predicted concentration of purgeables that were not detected was small. In North York 7 of the 10 purgeables predicted by the Level II model, but not observed, had concentrations of <5 μg/l with 3 compounds having concentrations <MDL. Table 23 summarizes the number of purgeables predicted but not detected in each concentration range for both the York and North York catchments at both levels of model application.

TABLE 23. CONCENTRATION OF PURGEABLE COMPOUNDS PREDICTED BUT NOT DETECTED

LOCATION	MODEL LEVEL	TOTAL NO. PURGEABLES PRED/NOT DET.	NUMBER <MDL	NUMBER <5 μg/l (including those <MDL)
York	I	8	5	6
	II	6	3	4
North York	I	7	3	5
	II	10	3	7

Dichloromethane was the single purgeable compound detected but not predicted by the Level I model. This highlights one weakness of the A.D. Little data base. Due to analytical difficulties during most of their study, quantitative data for dichloromethane was not available. In contrast, great care was exercised in this study in both sampling and analysis to ensure no external dichloromethane contamination.

On the whole, model performance was good in predicting the species of organic compounds or metals present in the wastewaters. Level II modelling gave improved predictive accuracy in the York catchment and somewhat poorer accuracy for the North York catchment.

The first quantitative measure of model performance is summarized in Table 24 from the individual results presented in Tables 20 and 21. Table 24 gives the number of times predicted concentrations fell within 1/2 log and 1 log of observed results for each of the HC groups. The Table also provides the percentage of the total number of compounds in each group represented by the compounds with predicted concentrations within 1/2 log and 1 log of observed results.

TABLE 24. SUMMARY BY HC GROUP OF THE COMPARISON OF OBSERVED AND PREDICTED HC CONCENTRATIONS

LOCATION	MODEL LEVEL	CRITERIA	PURGEABLE		EXTRACTABLE ACID		EXTRACTBLE B-N		METALS AND CN^-		TOTAL	
			NO.	%	NO.	%	NO.	%	NO.	%	NO.	%
York	I	1/2 Log	3	20	0	0	4	50	7	88	14	41
		1 Log	11	73	1	33	6	75	8	100	26	76
	II	1/2 Log	6	40	0	0	5	63	6	75	17	50
		1 Log	12	80	2	67	7	88	7	88	28	82
North York	I	1/2 Log	7	37	0	0	3	38	2	25	12	32
		1 Log	15	79	1	33	5	63	5	63	26	68
	II	1/2 Log	5	26	0	0	3	38	3	38	11	29
		1 Log	15	79	2	67	5	63	5	63	27	71

For the York catchment, 26 HCs or 76% were predicted by the Level I model with concentrations within 1 log of observed results. Fourteen of these HCs or 41% had concentrations within 1/2 log of predicted results. The Level II model gave improved accuracy with 28 HCs or 82% with concentrations within 1 log of observed results and 17 HCs or 50% within 1/2 log of predicted results. Best model performance was observed in the metals and cyanide group where only mercury concentrations were notably over-predicted (i.e observed Hg = 0.24 μg/l versus Level I Hg = <1.5 μg/l and Level II Hg = 4.9 μg/l). Excluding mercury, Level II predictions were generally lower in concentration reflecting the influence of the cooling water component in the calculations returned to the combined sewerage in York but is assumed to contain no contaminants. The Level I procedures do not make a separate allowance for this component.

Poorest model performance was observed in the acid extractable group although with only three compounds represented, great significance should not be attached to these results. Again, Level II predicted concentrations were lower than Level I, and therefore, closer to observed values.

The Level I modelling of the York catchment gave satisfactory results for the purgeable group with 73% of predicted concentrations within 1 log of observed and 20% within 1/2 log. Level II modelling yielded an improved predictive accuracy of 80% for the 1 log criteria and provided substantial improvement at 1/2 log such that 40% of predicted purgeable concentrations were within 1/2 log of observed results. Notable differences between predicted and observed results occurred for dichloromethane, ethyl benzene and toluene. Both ethyl benzene (398 μg/l) and toluene (120 μg/l) were observed in concentrations far exceeding any other purgeable compound with the exception of dichloromethane suggesting possibly atypical discharges of these compounds.

Modelling of base-neutral extractables was satisfactory at both levels of model application with Level II giving improved predictive accuracy. Level I modelling gave 75% of the predicted results within 1 log of observed values and 50% of the predicted results within 1/2 log. Eighty eight (88) percent of Level II predicted concentrations were within 1 log of observed results while 63% were within 1/2 log. Diethyl phthalate was not observed but was predicted by both levels of the model (<10 μg/l in both cases). Phenanthrene was observed (1.4 μg/l) but not predicted in either case.

The North York catchment was considerably more complex industrially than York. As a result, one might expect a reduction in predictive accuracy and indeed this was the case. Using Level I procedures, an overall accuracy of 68% of predicted concentrations within 1 log of observed values was achieved with 32% within 1/2 log. Level II modelling gave viturally the same results with 71% of predicted values falling within 1 log of observed and 29% falling within 1/2 log.

Poorest predictive performance was again within the acid extractable group where Level I predictions fell within 1 log of observations for only 1 of the three compounds in the group. Level II showed improvements accuracy with 2 of 3 predicted values within 1 log of observed.

Predicted concentrations of the selected metals and total cyanides with the exception of lead and mercury were signifcantly less than observed values. Lead and mercury were over-predicted by both model levels with Level II providing values considerably in excess of observed concentrations. The remaining metals and the total cyanides were all under-predicted. Cadmium showed the greatest discrepancy with about 1.5 - 2.0 log difference (observed 1620 μg/l; Level I - 15.4 μg/l; Level II - 36 μg/l). The elevated heavy metal and cyanide concentrations were most probably resultant from the electroplaters (SIC 3471) in the catchment. The Level I model does not explicitly account for inputs from this group, whereas, the Level II does contain specific HC data. Even so, industry practice is so variable that order of magnitude (1 log) predictive accuracy is the best that may be expected.

A total of 79% of all purgeable predictions were within 1 log of observed values at both levels of model application. However, Level I gave 37% of predicted concentrations within 1/2 log of observed values whereas Level II gave only 26% within 1/2 log.

Dichloromethane and toluene showed the greatest discrepancies between observed and predicted results.

Both model levels gave exactly the same results for the base-neutral group with 63% of predicted values within 1 log of observed and 38% within 1/2 log. The greatest disparity between predicted and observed concentration was noted for isophrone, which was not detected but predicted by Level II in a concentration of 664 μg/l. The excessively high predicted value of isophrone comes from the data base concentration of 44,000 μg/l for SIC 2893 (printing inks).

It is interesting to note that eventhough only 25% of the industrial water use in the North York catchment was covered by the data specific to individual SIC groups, nevertheless, Level II predictions were generally good. This suggests that as long as key industrial sectors are covered by specific data that the remainder and in this case the bulk of industrial wastewater is reasonably well described by the A.D. Little data base.

Observed and predicted daily HC loadings are presented in Tables 25 and 26 for the York and North York catchments. The loading comparison is summarized in Table 27. Overall predictive accuracy for York was quite good with 79% of predicted loadings within 1 log of observed for Level I modelling and 47% within 1/2 log. Level II modelling improved accuracy with 82% of predictions falling within 1 log of observations and 59% falling within 1/2 log. Predictive performance within HC groups followed the same pattern exhibited by the predicted and observed HC concentrations. Accuracy was in general, better for the loading predictions. For example, in the purgeable groups the Level I model predicted 80% of loadings within 1 log of observations and 40% within 1/2 log.

Predictive accuracy was also good for the North York catchment. Level I modelling gave 71% of predicted values within 1 log and 32% within 1/2 log of observed loadings. Level II provided comparable accuracy at 1 log but gave 42% of predictions within 1/2 log of observations. Group predictive accuracy also followed much the same pattern exhibited by the concentration data.

In summary, the evaluation presented in this chapter has shown that HAZPRED is capable of predicting the incidence, concentration and loading of HCs to within the desired accuracy for catchments of quite diverse characteristics. The Level II model, although requiring greater effort in terms of input data does provide better predictive accuracy as evidenced by the comparisons of concentrations and loading for both catchments. The model data base does have certain weaknesses such as the lack of dichloromethane data and the tendency to overpredict mercury concentrations. However, with the inherent flexibility of HAZPRED, future data can be readily entered to improve the data base.

TABLE 25. COMPARISON OF OBSERVED AND PREDICTED HC LOADINGS - YORK CATCHMENT

		LEVEL I			LEVEL II		
COMPOUND	OBSERVED LOADING gm/day	PREDICTED LOADING gm/day	1/2 LOG	1 LOG	PREDICTED LOADING gm/day	1/2 LOG	1 LOG
Purgeable							
Benzene	4.9	<2.5	YES	YES	3.6	YES	YES
Bromodichloromethane	(<0.6)	<2.5	YES	YES	<2.5	YES	YES
Carbon Tetrachloride	(<0.6)	12.9	NO	NO	5.6	NO	YES
Chloroethane	(<0.6)	(<1.3)	YES	YES	34.8	NO	NO
Chloroform	15.3	8.6	YES	YES	5.8	YES	YES
Chlorobenzene	(<0.6)	<2.5	YES	YES	(<0.3)	YES	YES
Dibromochloromethane	(<0.6)	<3.8	NO	YES	(<0.4)	YES	YES
1,1 Dichloroethane	(<0.6)	<3.8	NO	YES	(<0.4)	YES	YES
1,2 Dichloroethane	(<0.6)	<2.5	YES	YES	<2.5	NO	YES
1,2-t Dichloroethylene	(<0.6)	5.3	NO	YES	<2.5	NO	YES
Dichloromethane	568	(<0.4)	NO	NO	8.8	NO	NO
Ethyl Benzene	856	46.5	NO	NO	23.2	NO	NO
Tetrachloroethylene	<6.5	38.6	NO	YES	16.2	YES	YES
Toluene	258	26.8	NO	YES	35.9	NO	YES
1,1,1 Trichloroethane	<6.5	41.2	NO	YES	11.4	YES	YES
Extractable-Acid							
2-4 Dimethyl Phenol	<5.4	34.3	NO	YES	<25.2	NO	YES
Pentachlorophenol	(<0.8)	44.2	NO	NO	<44.2	NO	NO
Phenol	<3.4	67.4	NO	NO	<25.2	NO	YES
Extractable Base-Neutral							
Bis(2-Ethyl-Hexyl) Phthalate	45.2	26.3	YES	YES	<25.2	YES	YES
Butyl Benzyl Phthalate	17.0	83.6	NO	YES	<25.2	YES	YES
Di-n-Butyl Phthalate	13.8	39.4	YES	YES	<25.2	YES	YES
Dichlorobenzene	4.5	174	NO	NO	39.6	NO	YES
Diethyl Phthalate	(<1.1)	<25.2	NO	NO	<25.2	NO	NO
Di-n-Octyl Phthalate	<3.2	(<2.5)	YES	YES	(<2.5)	YES	YES
Naphthalene	5.8	25.2	NO	YES	<25.2	NO	YES
Phenanthrene	3.0	(<1.9)	YES	YES	(<1.9)	YES	YES
Metals and CN⁻							
Cadmium	12.5	11.1	YES	YES	6.1	YES	YES
Chromium	101.1	343	NO	YES	93.4	YES	YES
Copper	254	126	YES	YES	88.4	YES	YES
Lead	260	240	YES	YES	136.3	YES	YES
Mercury	0.5	<3.8	NO	YES	12.4	NO	NO
Nickel	25.8	53	YES	YES	<39.1	YES	YES
Zinc	482	593	YES	YES	452	YES	YES
Total CN⁻	25.8	42.4	YES	YES	<37.9	YES	YES

TABLE 26. COMPARISON OF OBSERVED AND PREDICTED HC LOADINGS - NORTH YORK CATCHMENT

		LEVEL I			LEVEL II		
COMPOUND	OBSERVED LOADING gm/day	PREDICTED LOADING gm/day	1/2 LOG	1 LOG	PREDICTED LOADING gm/day	1/2 LOG	1 LOG
Purgeable							
Benzene	15.5	10.2	YES	YES	142	NO	YES
Bromodichloromethane	(<1.9)	10.2	NO	YES	8.0	NO	YES
Carbon Tetrachloride	(<1.9)	154	NO	NO	13.1	NO	NO
Chloroethane	(<1.9)	(<3.7)	YES	YES	409	NO	NO
Chloroform	304	73.1	NO	YES	296	YES	YES
Chlorobenzene	(<1.9)	<7.3	NO	YES	<5.7	YES	YES
Dibromochloromethane	(<1.9)	<11	NO	YES	8.5	NO	YES
1,1 Dichloroethane	(<1.9)	8.8	NO	YES	8.0	NO	YES
1,2 Dichloroethane	(<1.9)	<7.3	NO	YES	70.5	NO	NO
1,1 Dichloroethylene	110	62.9	YES	YES	39.8	YES	YES
1,2-t Dichloroethylene	(<1.9)	65.1	NO	NO	40.9	NO	NO
Dichloromethane	1,338	(<0.7)	NO	NO	324	NO	YES
1,2 Dichloropropane	(<1.9)	(<0.7)	YES	YES	<5.7	YES	YES
Ethyl Benezene	530	549	YES	YES	864	YES	YES
Tetrachloroethylene	84	410	NO	YES	279	NO	YES
1,1,1 Trichloroethane	1,002	468	YES	YES	330	YES	YES
1,1,2 Trichloroethane	(<1.9)	(<0.7)	YES	YES	<5.7	YES	YES
Trichloroethylene	536	154	NO	YES	205	YES	YES
Toluene	1,889	351	NO	YES	375	NO	YES
Extractable-Acid							
2,4 Dimethyl Phenol	84	402	NO	YES	239	YES	YES
Pentachlorophenol	(<2.3)	62.2	NO	NO	159	NO	NO
Phenol	53	739	NO	NO	478	NO	YES
Extractable Base-Neutral							
Bis(2 Ethyl-Hexyl) Phthalate	58.8	241	NO	YES	205	NO	YES
Butyl Benzyl Phthalate	5.8	929	NO	NO	557	NO	NO
Di-n-Butyl Phthalate	142	380	YES	YES	245	YES	YES
Dichlorobenzene	22	2,048	NO	NO	1,217	NO	NO
Diethyl Phthalate	(<3.2)	<73.1	NO	NO	(<5.7)	YES	YES
Isophrone	(<0.3)	(<7.3)	YES	YES	3,776	NO	NO
Naphthalene	56.2	278	NO	YES	171	YES	YES
Phenanthrene	3.9	(<5.5)	YES	YES	(<4.3)	YES	YES
Metals and CN^-							
Cadmium	10,470	113	NO	NO	205	NO	NO
Chromium	18,380	3,935	NO	YES	6,164	YES	YES
Copper	1,474	746	YES	YES	1,416	YES	YES
Lead	989	1,812	YES	YES	6,614	NO	YES
Mercury	2.1	11	NO	YES	69.9	NO	NO
Nickel	3,865	607	NO	YES	2,514	YES	YES
Zinc	49,474	4,843	NO	NO	5,914	NO	YES
Total CN^-	19,273	490	NO	NO	591	NO	NO

TABLE 27. SUMMARY BY HC GROUP OF THE COMPARISON OF OBSERVED AND PREDICTED HC LOADINGS

LOCATION	MODEL LEVEL	CRITERIA	PURGEABLE		EXTRACTABLE ACID		EXTRACTBLE B-N		METALS AND CN^-		TOTAL	
			NO.	%	NO.	%	NO.	%	NO.	%	NO.	%
York	I	1/2 Log	6	40	0	0	4	50	6	75	16	47
		1 Log	12	80	1	33	6	75	8	100	27	79
	II	1/2 Log	8	53	0	0	5	63	7	88	20	59
		1 Log	12	80	2	67	7	88	7	88	28	82
North York	I	1/2 Log	7	37	0	0	3	38	2	25	12	32
		1 Log	16	84	1	33	5	63	5	63	27	71
	II	1/2 Log	8	42	1	33	4	50	3	38	16	42
		1 Log	15	79	2	67	5	63	5	63	27	71

6.0 MODEL APPLICATION

The HAZPRED model is written in Basic for the IBM PC microcomputer or equivalent (DOS 2.0 operating system). The model is wholly interactive and requires no prior knowledge of computers or programming to implement. The model user is given the option of modelling by Level I or Level II procedures. Model input requirements vary according to the level of modelling selected. Table 28 presents the input requirements for both model levels.

In the event Level I procedures are selected, the model requires only that the total industrial wastewater flowrate is known. The estimate of the total is developed by summing the water use data for individual industries and applying an appropriate return factor. Level II procedures also necessitate the collection of water use data for individual industries. However, if Level II is specified additional effort will be required for the following:

1) To categorize industries according to their SIC code group.
2) To determine cooling water and actual process and sanitary wastewater flowrates for major water using industries (>1% of total industrial water usage) and for industries in critical SIC groups defined as less than major water consumers.

TABLE 28. HAZPRED INPUT DATA REQUIREMENTS

INPUT DATA COMMON TO BOTH LEVELS	ADDITIONAL DATA LEVEL I ONLY	ADDITIONAL DATA LEVEL II ONLY
° Residential Population (POP) ° Residential per Capita Wastewater Generation (RWW) ° Commercial Wastewater Flowrate (CWW) ° Dry Weather Infiltration Rate (DWI) ($DWI_1 = DWI_2$)	° Total Industrial Wastewater Flowrate (IWW)	° Total Industrial Cooling Water Flowrate (ICW) ° Industrial Process and Sanitary Wastewater Flowrate for each SIC Category (IPW_k)

Note: It must be emphasized that the above are wastewater flowrates already adjusted for return factors where appropriate.

The categorization of industry required by Level II modelling should not entail significant manpower or extra expense since modestly priced commercial services (e.g. Scott's Directory) are available which will provide computerized listings sorted by the SIC group of the industries in any selected area. Matching water use to SIC data to develop water use estimates for each industrial category also does not require significant effort. The necessity of interviewing industries to establish the cooling water and process water fractions can however, add considerably to the manpower required for applying Level II. Experience from this study indicates that typically between 0.1 to 0.25 man-days per industry are required to obtain necessary data.

HAZPRED output is user selected and can include:

1) Predicted industrial wastewater concentrations.
2) Predicted overall wastewater concentrations.
3) Yearly loadings of HCs originating from residential, commercial and industrial sewer use and total yearly loadings.
4) A summary of input data.

Both metric and imperial units are available for flow data. All loadings are outputed at kg/yr and all concentration data is given in units of μg/l.

The listing of the HAZPRED program and sample model output for the York and North York catchments using both levels of model application are presented in Appendix 4.

7.0 PREDICTION OF HC LOADINGS

The Level II model was applied to predict HC loadings for both catchments. The loading data for the residential, commercial and industrial wastewater components and for the wastewater as a whole, are presented in Tables 29 and 30 for York and North York catchments respectively.

Not suprisingly, the HC loadings are totally dominated by industrial contributions in North York. In York, with the smaller industrial base and large residential population industry is not quite so dominant. For example, in the purgeable group residential wastewater contributes the majority of the chloroform and tetrachloroethylene loadings. Similarly, in the extractables a fraction of the phenol and the preponderance of the phthalate loading come from residential sources. Copper, lead, zinc, arsenic and antimony all have significant residential loadings.

TABLE 29. PREDICTED ANNUAL HC LOADINGS - YORK CATCHMENT

CONTAMINANT	COMPONENT			
	RESIDENTIAL	COMMERCIAL	INDUSTRIAL	TOTAL
	kg/yr	kg/yr	kg/yr	kg/yr
Purgeable				
Acrylonitrile	0.00	0.00	22	22
Benzene	0.07	0.04	3.41	3.5
Bromodichloromethane	0.00	0.01	0.11	0.13
Carbon Tetrachloride	0.00	0.00	1.38	1.4
Chloroethane	0.00	0.00	8.9	8.9
Chloroform	1.00	0.10	0.70	1.8
1,2 Dichloroethane	0.03	0.00	0.27	0.31
1,1 Dichloroethylene	0.00	0.00	0.35	0.35
1,2-t Dichloroethylene	0.00	0.02	0.33	0.35
Dichloromethane	0.00	0.00	2.2	2.2
Ethyl Benzene	0.13	0.04	5.8	5.9
Tetrachloroethylene	2.09	0.31	2.36	4.77
Toluene	0.86	0.16	8.4	9.4
1,1,1 Trichloroethane	0.76	0.04	2.3	3.1
Trichloroethylene	0.13	0.19	0.77	1.1
Extractable-Acid				
2,4 Dimethyl Phenol	0.23	0.00	1.8	2.1
Pentachlorophenol	0.40	0.09	2.3	2.8
Phenol	1.9	0.07	43	6.3
Extractable Base-Neutral				
Bis (2-Ethyl-Hexyl) Phthalate	2.3	0.11	2.5	4.9
Butyl Benzyl Phthalate	2.3	0.16	4.2	6.6
Di-n-Butyl Phthalate	3.0	0.17	2.4	5.5
Dichlorobenzenes	0.93	0.11	9.3	10.4
Diethyl Phthalate	3.3	0.08	0.00	3.3
Naphthalene	0.70	0.04	1.4	2.1
Nitrobenzene	0.00	0.00	0.30	0.30
Metals and CN^-				
Antimony	0.90	0.00	0.11	1.0
Arsenic	1.6	0.04	0.22	1.9
Cadmium	0.60	0.01	1.1	1.7
Chromium	5.4	0.83	19	26
Copper	24	0.80	4.9	30
Lead	32	0.73	11.6	45
Mercury	0.13	0.01	3.1	3.2
Nickel	1.4	0.18	3.8	5.4
Selenium	1.3	0.05	0.06	1.4
Silver	0.73	0.04	3.7	5.4
Zinc	71	2.0	64	137

TABLE 30. PREDICTED ANNUAL HC LOADINGS - NORTH YORK CATCHMENT

CONTAMINANT	COMPONENT		
	COMMERCIAL	INDUSTRIAL	TOTAL
	kg/yr	kg/yr	kg/yr
Purgeable			
Acrylonitrile	0.00	368	368
Benzene	1.4	52	53
Bromodichloromethane	0.53	2.5	3.0
Carbon Tetrachloride	0.05	48	48
Chlorobenzene	0.00	1.2	1.2
Chloroethane	0.00	152	152
Chloroform	3.5	23	27
Dibromochloromethane	0.37	2.8	3.2
1,1 Dichloroethane	0.05	2.9	2.9
1,2 Dichloroethane	0.05	7.5	7.6
1,1 Dichloroethylene	0.16	14.6	14.6
1,2-t Dichloroethylene	0.79	14.4	15.2
1,2 Dichloropropane	0.00	1.2	1.2
Dichloromethane	0.00	119	119
Ethyl Benzene	1.6	318	320
Tetrachloroethylene	11.3	93	105
Toluene	5.8	135	141
1,1,1 Trichloroethane	1.5	121	122
1,1,2 Trichloroethane	0.00	0.26	0.26
Trichloroethylene	6.8	69	76
Extractable-Acid			
2,4 Dimethyl Phenol	0.00	88	88
Pentachlorophenol	3.1	56	59
Phenol	2.4	176	178
Extractable Base-Neutral			
Bis (2-Ethyl-Hexyl) Phthalate	4.1	72	77
Butyl Benzyl Phthalate	5.6	201	207
Di-n-Butyl Phthalate	6.2	85	92
Dichlorobenzene	4.0	448	452
Diethyl Phthalate	3.0	0.43	3.4
Isophorone	0.00	1396	1396
Naphthalene	1.4	62	63
Metals and CN$^-$			
Antimony	0.16	26	26
Arsenic	1.4	6.3	7.7
Cadmium	0.32	75	75
Chromium	30	2253	2283
Copper	29	499	528
Lead	26	2423	2449
Mercury	0.21	26	26
Nickel	6.5	924	930
Selenium	1.7	1.8	3.5
Silver	1.5	179	181
Thallium	0.05	0.99	100
Zinc	73	2125	2192

8.0 CONCLUSIONS AND RECOMMENDATIONS

8.1 Conclusions

HAZPRED Model Validation

1) The characteristics of the two pilot catchments, in terms of land-use, sewerage and industrial characteristics, were so markedly different as to provide a full test of HAZPRED dry weather predictive ability under a wide range of input conditions.

2) HAZPRED Level II modelling predicted dry weather wastewater quantities to within 20% of observed results in the York catchment and to within 29% of observations in the North York catchment. Level I predictions were within 16% of observed values for York and within 53% for North York.

3) HAZPRED Level II procedures are more accurate in predicting wastewater quantities particularly where large quantities of cooling water are diverted to storm sewers or where large volumes are incorporated into products.

4) HAZPRED predicted the incidence of certain organic HCs, mostly in the purgeable group that were not observed. Level I modelling for York predicted 10 compounds (8 purgeables) not detected, whereas, Level II predicted 8 compounds (6 purgeables) with no observed analog. In North York, Levels I and II predicted 9 and 12 compounds (7 and 10 purgeables) respectively that were not observed.

5) Few organic HCs were detected, but not predicted. HAZPRED Level I and II modelling predicted concentrations <IDL for observed compounds in 3 and 2 cases respectively for York and in 2 and 1 cases respectively for North York.

6) The predicted incidence of the selected group of metals and of the total cyanides matched perfectly with observations at both levels of model application in both catchments.

7) HAZPRED predictions of dry weather wastewater concentrations of HCs compared favourably with observations.
Level II modelling of York wastewater resulted in 82% of all predicted concentrations within 1 log of observed values and 50% within 1/2 log. Level I modelling produced 76% of predicted concentrations within 1 log of observed results and 41% within 1/2 log.
Level I modelling of North York wastewater gave 68% of predictions within 1 log of observed concentrations and 32% within 1/2 log. Application of Level II for North York gave results comparable to Level I with 71% of predicted values within 1 log of observed concentrations and 29% within 1/2 log.

8) Extractable-Acid group concentrations were, in general, poorly predicted. In contrast, predictions for the more numerous purgeable group were consistently accurate.

9) Isophorone, diethyl phthalate and mercury concentrations were consistently overpredicted. Dichloromethane, toluene and ethyl benzene concentrations were consistently underpredicted.

10) The correspondence of observed and predicted daily dry weather HC loadings is good for both catchments and both levels of model application. York Level I modelling gave 79% of predicted loadings within 1 log of observed values and 47% within 1/2 log. Level II modelling was more accurate and gave 82% of predictions within 1 log of observations and 59% within 1/2 log.
In North York, 71% of Level I predictions were within 1 log of observed loadings and 32% within 1/2 log. Level II gave somewhat better accuracy with 71% within 1 log and 42% within 1/2 log.

11) HAZPRED Level II modelling can provide satisfactory predictive accuracy for HC concentrations and loadings with as little as 25% of industrial water-use covered by HC data specific to individual SIC groups given that the key industrial sectors are covered.

Field Program

12) Wastewaters from both catchments were of high strength with respect to lumped organic parameters (i.e. BOD_5, COD) reflecting the industrial contributions in each catchment.

13) A total of 20 purgeables and 16 extractable compounds (7 acid and 9 base-neutral) were observed in any sample from either site. Neither any of the pesticides nor the PCBs were found in detectable quantities in any sample.

14) Dichloromethane, ethyl benzene, toluene, benzene and chloroform were most often detected in the purgeable group. Only phenol and 2,4 dimethyl phenol were detected with any regularity in the acid-extractables. The phthalates and dichlorobenzenes were most prevalent in the base-neutral extractables. The xylene isomers and styrene were the most frequently detected non-priority organic pollutants in both catchments.

15) Purgeable compounds were the organics observed in the highest concentrations in both catchments. Average concentrations were on the same order for both York and North York.

16) The group of selected metals and the total cyanides were observed in all samples from both catchments. Metals and cyanide concentrations were 1 to 2 orders of magnitude greater in the North York wastewater.

Loading Prediction

17) For the majority of HCs, industrial wastewater makes up the largest component of the total wastewater load. However, where the residential wastewater contribution is large, significant loadings of chloroform, the phthalates, phenol and copper, lead, zinc, arsenic and antimony come from residential sources.

8.2 Recommendations

1) The HAZPRED data base should be expanded through both additional literature review and field studies to incorporate data on non-characterized SIC groups. The scope of the data base should also be expanded to include organic pollutants of concern that are not presently on the EPA list.

2) Possible refinements to the HAZPRED data base should be investigated. Potential improvements requiring evaluation should include:

   i) The feasibility of dividing major SIC groups into sub-groups (e.g. SIC 3471 electroplating could be sub-divided according to the type of plating operation (i.e. precious metal, chrome, mixed, etc.) and of developing HC data specific to each sub-group.

   ii) The feasibility of developing HC concentration data within a SIC group or sub-group specific to industries with and without pretreatment.

3) The HAZPRED model should be further developed to enable prediction of HCs in stormwater runoff and combined sewer overflow. The overall model (wet + dry) should then be validated by a well designed data collection program in at least two catchments of diverse characteristics.

9.0 BIBLIOGRAPHY

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APPENDIX 1

EPA LIST OF 129 PRIORITY POLLUTANTS

EPA PRIORITY POLLUTANT LIST

TRACE ORGANICS

VOLATILE ORGANICS GROUP

- Benzene
- Bromodichloromethane
- Bromoform
- Bromomethane
- Carbon Tetrachloride
- Chlorobenzene
- Chloroethane
- 2-Chloroethylvinyl ether
- Chloroform
- Chloromethane
- bis-Chloromethyl ether
- Dibromochloromethane
- Dichlorodifluoromethane
- 1,1 - Dichloroethane
- 1,2 - Dichloroethane
- 1,1 - Dichloroethylene
- trans-1, 2 - Dichloroethylene
- 1,2 - Dichloropropane
- cis- 1,3 - Dichloropropene
- trans - 1,3 - Dichloropropene
- Ethylbenzene
- Methylene Chloride
- 1, 1, 2, 2 - Tetrachloroethane
- 1, 1, 2, 2 - Tetrachloroethene
- Toluene
- 1, 1, 1 - Trichloroethane
- 1, 1, 2 - Trichloroethane
- Trichloroethylene
- Trichlorofluoromethane
- Vinyl Chloride

SEMI-VOLATILE ORGANICS GROUP

Base-Neutrals

Polynuclear Aromatic Hydrocarbons, including
- Acenaphthene
- Acenaphthylene
- Anthracene
- Benzo (a) anthracene
- Benzo (b) fluoranthene
- Benzo (k) fluoranthene
- Benzo (ghi) perylene
- Benzo (a) pyrene
- Chrysene
- Dibenzo (ah) anthracene
- Fluoranthene
- Fluorene
- Indeno (1,2,3 - cd) pyrene
- Naphthalene
- Phenanthrene
- Pyrene

Chlorinated Benzenes, including
- 1, 2 - Dichlorobenzene
- 1, 3 - Dichlorobenzene
- 1, 4 - Dichlorobenzene
- 1, 2, 4 - Trichlorobenzene
- Hexachlorobenzene

Nitrosamines, including
- N-nitrosodimethylamine
- N-nitrosodiphenylamine
- N-nitrosodi-n-propylamine

Phthalate Esters, including
- Butyl Benzylphthalate
- Di-n-butylphthalate
- Diethylphthalate
- Dimethylphthalate
- Di-n-octylphthalate
- bis-(2-ethylhexyl)phthalate

Haloethers, including
- 4 - Bromophenyl phenyl ether
- bis (2-chloroethoxy) methane
- bis (2-chloroethyl) ether
- bis (2-chloroisopropyl) ether
- 4 - Chlorophenyl phenyl ether

Other compounds, including
- Benzidine
- 2 - Chloronaphthalene
- 3, 3'- Dichlorobenzidine
- 2, 4 - Dinitrotoluene
- 2, 6 - Dinitrotoluene
- 1, 2 - Diphenylhydrazine
- Hexachlorobutadiene
- Hexachlorocyclopentadiene
- Hexachloroethane
- Isophorone
- Nitrobenzene

Acids

- p - Chloro-m-cresol
- 2 - Chlorophenol
- 2, 4 - Dichlorophenol
- 2, 4 - Dimethylphenol
- 4, 6 - Dinitro-o-cresol
- 2, 4 - Dinitrophenol
- 2 - Nitrophenol
- 4 - Nitrophenol
- Pentachlorophenol
- Phenol
- 2, 4, 6 - Trichlorophenol

Pesticides and PCBs

- Aldrin
- alpha - BHC,
- beta - BHC
- gama - BHC (Lindane)
- delta - BHC
- Chlordane
- 4, 4' - DDD
- 4, 4' - DDE
- 4, 4' - DDT
- Dieldrin
- alpha - Endosulfan
- beta - Endosulfan
- Endosulfan Sulphate
- Endrin
- Endrin Aldehyde
- Heptachlor
- Heptachlor Epoxide
- PCB - 1016
- PCB - 1221
- PCB - 1232
- PCB - 1242
- PCB - 1248
- PCB - 1254
- PCB - 1260
- Toxaphene

MISCELLANEOUS GROUP

- Acrolein
- Acrylonitrile
- 2,3,7,8-tetrachlorodibenzo-p-dioxin
- Asbestos
- Cyanide
- Total Phenols

TRACE ELEMENTS

- Antimony
- Arsenic
- Beryllium
- Cadmium
- Chromium
- Copper
- Lead
- Mercury
- Nickel
- Selenium
- Silver
- Thallium
- Zinc

APPENDIX 2

MATRIX OF HC INCIDENCE AND FOR SELECTED SIC GROUPS

Recorded Concentrations of Priority Pollutants by SIC Group (EPA 1980 and AD Little 1979)

Contaminant			Sic Group												
	2200-99	2820-24	2834	2841	2844	2851	2893	3011-79	3111	3312	3321-25	3431	3471	3479	Other
HEPTACHLOREPOXIDE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
alpha-BHC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
beta-BHC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
gamma-BHC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
delta-BHC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCB-1242	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCB-1254	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCB-1221	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCB-1232	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCB-1248	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCB-1260	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCB-1016	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOXAPHENE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ANTIMONY	7.0	0.0	10.0	1.0	28.0	25.0	25.0	0.0	0.0	33.0	0.0	2700.0	0.0	3000.0	1.7
ARSENIC	10.0	5.0	0.0	11.0	10.0	52.0	25.0	0.0	0.0	660.0	0.0	56.0	0.0	75.0	3.2
ASBESTOS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BERYLLIUM	2.0	0.0	0.0	0.0	0.0	5.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CADMIUM	2.0	34.0	0.0	1.0	0.0	20.0	20.0	150.0	0.0	0.0	0.0	32.0	389.0	5.0	20.7
CHROMIUM	14.0	120.0	94.0	18.0	16.0	200.0	20000.0	280.0	80000.0	0.0	35.0	75.0	6830.0	6900.0	713.2
COPPER	40.0	83.0	180.0	35.0	22.0	500.0	800.0	135.0	173.0	0.0	300.0	400.0	2940.0	51.0	124.8
TOTAL CYANIDES	8.0	41.0	580.0	10.0	120.0	20.0	110.0	0.0	40.0	26000.0	6.0	0.0	866.0	12.0	90.7
LEAD	35.0	38.0	7.5	15.0	0.0	800.0	50000.0	390.0	1200.0	0.0	320.0	190.0	4060.0	140.0	323.7
MERCURY	0.6	5.0	1.0	76.0	0.0	1100.0	11.0	2.0	0.0	0.0	0.1	0.0	0.0	10.0	1.9
NICKEL	54.0	0.0	28.0	29.0	0.0	50.0	50.0	270.0	40.0	0.0	40.0	6900.0	7550.0	390.0	108.7
SELENIUM	35.0	5.0	0.0	0.0	16.0	0.0	0.0	10.0	0.0	410.0	0.0	42.0	0.0	0.0	0.9
SILVER	32.0	0.0	0.0	69.0	0.0	5.0	0.0	0.0	0.0	25.0	0.0	0.0	0.0	20.0	150.4
THALLIUM	3.0	0.0	24.0	0.0	0.0	5.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
ZINC	190.0	365000.0	500.0	67.0	150.0	10000.0	1000.0	4200.0	430.0	130.0	590.0	6800.0	5240.0	7600.0	860.0
2,3,7,8 TCDD	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Recorded Concentrations of Priority Pollutants by SIC Group (EPA 1980 and AD Little 1979)

Contaminant			Sic Group												
	2200-99	2820-24	2834	2841	2844	2851	2893	3011-79	3111	3312	3321-25	3431	3471	3479	Other
DIBROMOCHLOROMETHANE	0.0	0.0	0.0	0.0	0.0	0.0	43.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2
HEXACHLOROBUTADIENE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HEXACHLOROCYCLOPENTADIENE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ISOPHORONE	0.0	0.0	0.0	0.0	0.0	0.0	44000.0	0.0	0.0	2000.0	0.0	0.0	0.0	600.0	0.0
NAPHTHALENE	44.0	0.0	0.0	0.0	0.0	54.0	14.0	0.0	46.0	27500.0	0.0	0.0	0.0	5.0	50.7
NITROBENZENE	0.0	0.0	0.0	0.0	0.0	110.0	0.0	0.0	430.0	0.0	70.0	0.0	0.0	0.0	0.0
2-NITROPHENOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.0	0.0	770.0	10.0	0.0	0.0	0.0	0.0
4-NITROPHENOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.0	0.0	0.0	0.0	0.0
2,4-DINITROPHENOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4,6-DINITRO-O-CRESOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	14.0	0.0	0.0	0.0	0.0
N-NITROSODIMETHYLAMINE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
N-NITROSODIPHENYLAMINE	15.0	0.0	0.0	0.0	12.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
N-NITROSDI-N-PROPYLAMINE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PENTACHLOROPHENOL	52.0	0.0	230.0	77.0	0.0	750.0	660.0	0.0	0.0	395.0	21.0	0.0	0.0	0.0	10.1
PHENOL	55.0	62.5	0.0	30.0	0.0	110.0	5.0	185.0	3700.0	120000.0	100.0	0.0	0.0	16.0	135.8
BIS(2-ETHYLHEXYL)PHTHALATE	26.0	42.0	12.0	20.0	130.0	140.0	5.0	285.0	51.0	0.0	5.5	0.0	0.0	35.0	43.0
BUTYL BENZYL PHTHALATE	42.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.0	0.0	0.0	150.0	168.2
DI-N-BUTYL PHTHALATE	16.0	0.0	0.0	13.0	0.0	260.0	5.0	0.0	0.0	0.0	6.0	0.0	0.0	5.0	67.1
DI-N-OCTYL PHTHALATE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	41.0	0.0	0.0	29.0	0.0
DIETHYL PHTHALATE	6.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	56.0	0.0
DIMETHYL PHTHALATE	12.0	0.0	0.0	0.0	0.0	0.0	0.0	5.0	120.0	0.0	0.0	0.0	0.0	0.0	0.0
BENZO(A) ANTHRACENE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	150.0	9.0	0.0	0.0	56.0	0.0
BENZO(A) PYRENE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	360.0	0.0	0.0	0.0	5.0	0.0
3,4 BENZOFLUORANTHENE	5.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.0	0.0	0.0	35.0	0.0
BENZO(K) FLUORANTHENE	5.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.0	0.0	0.0	35.0	0.0
CHRYSENE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	320.0	0.0	0.0	0.0	23.0	0.0
ACENAPHTHYLENE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.0	3200.0	0.0	0.0	0.0	5.0	0.0
ANTHRACENE	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	47.0	0.0	2.0	0.0	0.0	64.0	0.0
BENZO(GHI)PERYLENE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
FLUORENE	15.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	370.0	44.0	0.0	0.0	30.0	0.0
PHENANTHRENE	0.0	0.0	0.0	1.8	0.0	0.0	0.0	0.0	47.0	0.0	2.0	0.0	0.0	64.0	0.0
DIBENZO(A,H)ANTHRACENE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
INDENO(1,2,3CD)PYRENE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PYRENE	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	760.0	6.0	0.0	0.0	16.0	0.0
TETRACHLOROETHYLENE	2.0	5.0	0.0	15.0	0.0	230.0	170.0	0.0	0.0	0.0	0.0	0.0	0.0	5.0	69.9
TOLUENE	26.0	5.0	190.0	0.0	0.0	2500.0	330.0	77.0	280.0	5700.0	0.0	0.0	0.0	5.0	52.3
TRICHLOROETHYLENE	47.0	0.0	0.0	12.0	0.0	52.0	1200.0	0.0	0.0	0.0	0.0	0.0	0.0	5.0	25.4
VINYL CHLORIDE	11.0	460.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ALDRIN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DIELDRIN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CHLORDANE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4,4'-DDT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4,4'-DDE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4,4'-DDD	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
alpha-ENDOSULFAN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
beta-ENDOSULFAN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ENDOSULFAN SULPHATE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ENDRIN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ENDRIN ALDEHYDE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HEPTACHLOR	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Recorded Concentrations of Priority Pollutants by SIC Group (EPA 1980 and AD Little 1979)

Contaminant	Sic Group													
	2200-99	2820-24	2934	2841	2844	2951	2893	3011-79	3111	3312	3321-25	3431	3471	3479	Other
ACENAPHTHENE	8.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	32.0	0.0	0.0	0.0	0.0	0.0	0.0
ACROLEIN	0.0	1841.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ACRYLONITRILE	0.0	21310.0	0.0	0.0	0.0	0.0	0.0	6000.0	0.0	2700.0	0.0	0.0	0.0	0.0	0.0
BENZENE	2.0	5.0	0.0	0.4	0.0	440.0	130.0	605.0	15.0	27000.0	0.0	0.0	0.0	5.0	1.2
BENZIDINE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	27.0	0.0	0.0	0.0	0.0	0.0	0.0
CARBON TETRACHLORIDE	0.0	5.0	0.0	0.0	0.0	14.0	96.0	177.0	0.0	0.0	0.0	0.0	0.0	0.0	28.4
CHLOROBENZENE	25.0	5.0	0.0	11.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.9
1,2,4-TRICHLOROBENZENE	410.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HEXACHLOROBENZENE	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1,2-DICHLOROETHANE	2.0	0.0	14.0	0.0	0.0	33.0	89.0	47.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6
1,1,1-TRICHLOROETHANE	7.8	0.0	0.0	0.0	0.0	82.0	560.0	0.0	0.0	0.0	0.0	0.0	0.0	5.0	85.1
HEXACHLOROETHANE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1,1-DICHLOROETHANE	14.0	5.0	0.0	0.0	0.0	5.0	21.0	0.5	20.0	0.0	0.0	0.0	0.0	18.0	1.6
1,1,2-TRICHLOROETHANE	0.0	0.0	0.0	0.0	0.0	5.0	5.0	0.0	10.0	0.0	0.0	0.0	0.0	0.0	0.0
1,1,2,2-TETRACHLOROETHANE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	10.0	0.0	0.0	0.0	0.0	0.0	0.0
CHLOROETHANE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2470.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BIS(CHLOROMETHYL)ETHER	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BIS(2-CHLOROETHYL)ETHER	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2-CHLOROETHYL VINYL ETHER	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2-CHLORONAPHTHALENE	5.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2,4,6-TRICHLOROPHENOL	20.0	0.0	0.0	7.3	0.0	0.0	0.0	0.0	3400.0	400.0	0.0	0.0	0.0	0.0	0.0
P-CHLORO-M-CRESOL	0.0	5.0	0.0	2.9	0.0	0.0	0.0	0.0	0.0	2200.0	0.0	0.0	0.0	0.0	0.0
CHLOROFORM	48.0	5.0	130.0	3.0	51.0	108.0	14.0	29.0	20.0	120.0	0.0	0.0	0.0	0.0	12.0
2-CHLOROPHENOL	0.0	0.0	0.0	96.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DICHLOROBENZENES	110.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	260.0	0.0	0.0	0.0	0.0	0.0	376.5
3,3'-DICHLOROBENZIDINE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1,1-DICHLOROETHYLENE	2.0	0.0	0.0	18.0	0.0	23.0	5.0	0.0	0.0	3.0	0.0	0.0	0.0	0.0	11.6
1,2-T-DICHLOROETHYLENE	0.0	0.0	0.0	3.3	0.0	14.0	5.0	0.0	30.0	0.0	6.0	0.0	0.0	0.0	11.7
2,4-DICHLOROPHENOL	26.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20.0	0.0	0.0	0.0	0.0
1,2-DICHLOROPROPANE	100.0	0.0	0.0	0.0	0.0	12.0	22.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1,3-DICHLOROPROPYLENE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2,4-DIMETHYL PHENOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5000.0	11.0	0.0	0.0	21.0	74.0
2,4-DINITROTOLUENE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1900.0	4.0	0.0	0.0	0.0	0.0
2,6-DINITROTOLUENE	54.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	240.0	4.0	0.0	0.0	0.0	0.0
1,2-DIPHENYLHYDRAZINE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ETHYL BENZENE	54.0	2794.0	7.0	0.0	0.0	1200.0	5500.0	2.6	88.0	300.0	0.0	0.0	0.0	5.0	100.4
FLUORANTHENE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	950.0	1.0	0.0	0.0	40.0	0.0
4-CHLOROPHENYL PHENYL ETHER	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Recorded Concentrations of Priority Pollutants by SIC Group (EPA 1980 and AD Little 1979)

Contaminant	Sic Group													
	2200-99	2820-24	2834	2841	2844	2851	2893	3011-79	3111	3312	3321-25	3431	3471	3479	Other
4-BROMOPHENYL PHENYL ETHER	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BIS(2-CHLOROISOPROPYL)ETHER	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BIS(2-CHLOROETHOXY)METHANE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DICHLOROMETHANE	47.0	5.0	2400.0	19.0	63.0	790.0	820.0	19.0	0.0	0.0	0.0	0.0	0.0	5.0	0.0
CHLOROMETHANE	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BROMOMETHANE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BROMOFORM	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BROMODICHLOROMETHANE	6.6	5.0	0.0	0.0	0.0	27.0	0.0	0.0	10.0	0.0	0.0	0.0	0.0	0.0	1.6
TRICHLOROFLUOROMETHANE	90.0	5.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DICHLORODIFLUOROMETHANE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DIBROMOCHLOROMETHANE	0.0	0.0	0.0	0.0	0.0	0.0	43.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2
HEXACHLOROBUTADIENE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HEXACHLOROCYCLOPENTADIENE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ISOPHORONE	0.0	0.0	0.0	0.0	0.0	0.0	44000.0	0.0	0.0	2000.0	0.0	0.0	0.0	600.0	0.0
NAPHTHALENE	44.0	0.0	0.0	0.0	0.0	54.0	14.0	0.0	46.0	27500.0	0.0	0.0	0.0	5.0	50.7
NITROBENZENE	0.0	0.0	0.0	0.0	0.0	110.0	0.0	0.0	430.0	0.0	70.0	0.0	0.0	0.0	0.0
2-NITROPHENOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.0	0.0	770.0	10.0	0.0	0.0	0.0	0.0
4-NITROPHENOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.0	0.0	0.0	0.0	0.0
2,4-DINITROPHENOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4,6-DINITRO-O-CRESOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	14.0	0.0	0.0	0.0	0.0
N-NITROSODIMETHYLAMINE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
N-NITROSODIPHENYLAMINE	15.0	0.0	0.0	0.0	12.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
N-NITROSDI-N-PROPYLAMINE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PENTACHLOROPHENOL	52.0	0.0	230.0	77.0	0.0	750.0	660.0	0.0	0.0	395.0	21.0	0.0	0.0	0.0	10.1
PHENOL	55.0	62.5	0.0	30.0	0.0	110.0	5.0	185.0	3700.0	120000.0	100.0	0.0	0.0	16.0	135.8
BIS(2-ETHYLHEXYL)PHTHALATE	26.0	42.0	12.0	20.0	130.0	140.0	5.0	285.0	51.0	0.0	5.5	0.0	0.0	35.0	43.0
BUTYL BENZYL PHTHALATE	42.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.0	0.0	0.0	150.0	168.2
DI-N-BUTYL PHTHALATE	16.0	0.0	0.0	13.0	0.0	260.0	5.0	0.0	0.0	0.0	6.0	0.0	0.0	5.0	67.1
DI-N-OCTYL PHTHALATE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	41.0	0.0	0.0	29.0	0.0
DIETHYL PHTHALATE	6.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	56.0	0.0
DIMETHYL PHTHALATE	12.0	0.0	0.0	0.0	0.0	0.0	0.0	5.0	120.0	0.0	0.0	0.0	0.0	0.0	0.0
BENZO(A) ANTHRACENE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	150.0	9.0	0.0	0.0	56.0	0.0
BENZO(A) PYRENE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	360.0	0.0	0.0	0.0	5.0	0.0
3.4 BENZOFLUORANTHENE	5.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.0	0.0	0.0	35.0	0.0
BENZO(K) FLUORANTHENE	5.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.0	0.0	0.0	35.0	0.0
CHRYSENE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	320.0	0.0	0.0	0.0	23.0	0.0
ACENAPHTHYLENE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.0	3200.0	0.0	0.0	0.0	5.0	0.0
ANTHRACENE	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	47.0	0.0	2.0	0.0	0.0	64.0	0.0
BENZO(GHI)PERYLENE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
FLUORENE	15.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	370.0	44.0	0.0	0.0	30.0	0.0

Recorded Concentrations of Priority Pollutants by SIC Group (EPA 1980 and AD Little 1979)

Contaminant	Sic Group 2200-99	2820-24	2834	2841	2844	2851	2893	3011-79	3111	3312	3321-25	3431	3471	3479	Other
PHENANTHRENE	0.0	0.0	0.0	1.8	0.0	0.0	0.0	0.0	47.0	0.0	2.0	0.0	0.0	64.0	0.0
DIBENZO(A,H)ANTHRACENE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
INDENO(1,2,3CD)PYRENE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PYRENE	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	760.0	6.0	0.0	0.0	16.0	0.0
TETRACHLOROETHYLENE	2.0	5.0	0.0	15.0	0.0	230.0	170.0	0.0	0.0	0.0	0.0	0.0	0.0	5.0	69.9
TOLUENE	26.0	5.0	190.0	0.0	0.0	2500.0	330.0	77.0	280.0	5700.0	0.0	0.0	0.0	5.0	52.3
TRICHLOROETHYLENE	47.0	0.0	0.0	12.0	0.0	52.0	1200.0	0.0	0.0	0.0	0.0	0.0	0.0	5.0	25.4
VINYL CHLORIDE	11.0	460.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ALDRIN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DIELDRIN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CHLORDANE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4,4'-DDT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4,4'-DDE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4,4'-DDD	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
alpha-ENDOSULFAN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
beta-ENDOSULFAN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ENDOSULFAN SULPHATE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ENDRIN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ENDRIN ALDEHYDE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HEPTACHLOR	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HEPTACHLOREPOXIDE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
alpha-BHC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
beta-BHC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
gamma-BHC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
delta-BHC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCB-1242	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCB-1254	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCB-1221	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCB-1232	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCB-1248	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCB-1260	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCB-1016	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOXAPHENE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ANTIMONY	7.0	0.0	10.0	1.0	28.0	25.0	25.0	0.0	0.0	33.0	0.0	2700.0	0.0	3000.0	1.7
ARSENIC	10.0	5.0	0.0	11.0	10.0	52.0	25.0	0.0	0.0	660.0	0.0	56.0	0.0	75.0	3.2
ASBESTOS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BERYLLIUM	2.0	0.0	0.0	0.0	0.0	5.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CADMIUM	2.0	34.0	0.0	1.0	0.0	20.0	20.0	150.0	0.0	0.0	0.0	32.0	389.0	5.0	20.7
CHROMIUM	14.0	120.0	94.0	18.0	16.0	200.0	20000.0	280.0	80000.0	0.0	35.0	75.0	6830.0	6900.0	713.2
COPPER	40.0	83.0	180.0	35.0	22.0	500.0	800.0	135.0	173.0	0.0	300.0	400.0	2940.0	51.0	124.8

Recorded Concentrations of Priority Pollutants by SIC Group (EPA 1980 and AD Little 1979)

Contaminant	Sic Group														
	2200-99	2820-24	2834	2841	2844	2951	2893	3011-79	3111	3312	3321-25	3431	3471	3479	Other
TOTAL CYANIDES	8.0	41.0	580.0	10.0	120.0	20.0	110.0	0.0	40.0	26000.0	6.0	0.0	866.0	12.0	90.7
LEAD	35.0	38.0	7.5	15.0	0.0	800.0	50000.0	390.0	1200.0	0.0	320.0	190.0	4060.0	140.0	323.7
MERCURY	0.6	5.0	1.0	76.0	0.0	1100.0	11.0	2.0	0.0	0.0	0.1	0.0	0.0	10.0	1.9
NICKEL	54.0	0.0	28.0	29.0	0.0	50.0	50.0	270.0	40.0	0.0	40.0	6900.0	7550.0	390.0	100.7
SELENIUM	35.0	5.0	0.0	0.0	16.0	0.0	0.0	10.0	0.0	410.0	0.0	42.0	0.0	0.0	0.9
SILVER	32.0	0.0	0.0	69.0	0.0	5.0	0.0	0.0	0.0	25.0	0.0	0.0	0.0	20.0	150.4
THALLIUM	3.0	0.0	24.0	0.0	0.0	5.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
ZINC	190.0	365000.0	500.0	67.0	150.0	10000.0	1000.0	4200.0	430.0	130.0	590.0	6800.0	5240.0	7600.0	860.0
2,3,7,8 TCDD	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

APPENDIX 3

DETECTION LIMITS AND RECOVERIES FROM GC/MS ANALYSIS OF ORGANIC HAZARDOUS CONTAMINANTS

TABLE 3.1. PERCENT RECOVERY OF PURGEABLE ORGANICS

COMPOUND	METHOD DETECTION LIMIT (μg/l)	PERCENT RECOVERY	CV* (%)
Ethyl Ether	3	99	-
Chloromethane	3	nd	3.0
Dichlorodifluoromethane	3	nd	3.7
Vinyl Chloride	3	116	5.6
Trichlorofluoromethane	3	106	1.5
Chloroethane	3	105	7.8
Bromomethane	3	88	3.6
1,1 Dichloroethylene	3	113	2.8
Carbon Disulfide	3	102	-
3-Chloropropene	3	93	-
1,2 Dichloroethylene(trans)	3	95	7.1
1,1 Dichloroethane	3	82	2.6
Carbon Tetrachloride	3	75	0.5
1,1,1 Trichloroethane	3	56	2.4
Dichloromethane	3	107	5.3
Benzene	2	102	4.3
Trichloroethylene	3	112	14.9
Chloroform	3	87	2.4
Tetrachloroethylene	3	88	7.5
1,2 Dichloropropane	3	95	1.9
Toluene	2	97	3.3
1,2 Dichloroethane	3	100	4.5
Ethyl Benzene	2	92	1.7
P-Xylene	2	99	1.4
2-Chloroethyl Vinyl Ether	3	nd	3.3
M-Xylene	2	93	1.7
Bromodichloromethane	3	96	0.9
O-Xylene	2	98	3.4
1,3 Dichloropropene(trans)	3	88	3.0
1,3 Dichloropropene(cis)	3	88	3.1
Deuterated Chlorobenzene	3	-	2.0
Chlorobenzene	3	82	4.1
1,1,2 Trichloroethane	3	95	5.5
Styrene	3	96	-
Dibromochloromethane	3	95	4.9
Bromoform	3	85	3.5
1,1,2,2 Tetrachloroethane	3	71	10.6
Bis(2-Chloroethyl)Ether	10	15	-

* Coefficient of Variation

TABLE 3-2. DETECTION LIMITS AND % RECOVERY OF ACID EXTRACTABLE COMPOUNDS

ACIDIC COMPOUNDS	DERIV MWT	MDL (μg/l)	% RECOV #1	% RECOV #2	% RECOV DEUT
Phenol	94	1.6	31.8	49.0	
Deuterated Phenol	113	2.0		45.0	50.3
2-ChloroPhenol	142	3.0	86.8	68.4	
2,3 Dimethyl Phenol	136	2.5	53.6	19.7	54.1
p-Chloro-M-Cresol	156	2.0		10.6	8.0
2,4 Dichlorophenol	176	2.9	95.4	64.2	36.1
2,4,6 Trichlorophenol	210	3.3	64.1	60.6	46.5
2-Nitrophenol	153	2.0	86.9	63.4	75.0
2,4 Dinitrophenol	198	15.0		43.9	
4,6 Dinitro-O-Cresol	212	4.0	54.8	77.2	41.8
Pentachlorophenol	280	3.5	78.1	65.4	
4-Nitrophenol	153	2.1	29.8	28.0	
2,4-D	234	4.5	86.3	58.9	
Silvex	280	4.4	60.0	76.4	
D10 Phen	-		100.0	100.0	
D10 Anth	-		92.0	94.5	
Deut. 2-Nitrophenol	157		69.0	65.6	

TABLE 3-3. DETECTION LIMITS AND % RECOVERY OF BASE/NEUTRAL EXTRACTABLE COMPOUNDS

COMPOUNDS	DERIV MWT	MDL (µg/L)	% RECOV #1	% RECOV #2	% RECOV DEUT
1,4 Dichlorobenzene	146	0.4		78	76
1,3 Dichlorobenzene	146	0.4		90	
Bis(2-Chloroisopropyl)Ether	170	1.0		47	2.0
1,2 Dichlorobenzene	146	0.4		42	69
Nitro Benzene	123	0.5	1.3	58	100
N-Nitroso-Di-N-Propyl-Amine	130	0.5	2.8	57	
Hexachloroethane	234	3.0		51	
Isophorone	138	0.4	20.5	74	25
Bis(2-Chloro Ethoxy)Methane	172	0.9	9.6	85	
D_8 Naphthalene	136	0.4	10.3	75	100
Naphthalene	128	0.4	5.8	74	
1,2,4 Trichlorobenzene	180	1.3	1.5	78	
Hexachlorobutadiene	258	0.5	0.9	68	
Hexachlorocyclopentadiene	270	10.0		13	
2-Chloronaphthalene	162	0.8	17.6	52	
2,6 Dinitrotoluene	182	2.0	51.4	94	66
Dimethyl Phthalate	194	1.0	73.2	84	96
Acenaphthylene	152	0.5	36.2	63	
Acenaphthene	154	0.4	42.2	59	94
2,4 Dinitrotoluene	182	1.5	73.6	97	
Diethyl Phthalate	222	5.0	43.2	51	
4-Bromophenylphenylether	248	0.5	74.4	76	
Hexachloro Benzene	284	1.2	72.1	61	
Phenanthrene	178	0.3	68.8	75	
D-10 Anthracene	188		63.6	93	
Anthracene	178	0.3	91.5	91	
Di-n-Butyl Phthalate	278	0.4	64.7	66	100
Fluoranthene	202	0.6	>100.	44	
Benzidene	184	10.0		63	
Pyrene	202	0.5	76.9	99	44
Butyl/benzyl/phthalate	312	0.8	38.0	92	
Chrysene	228	0.4	35.0	83	26
Benzo(a)anthracene	228	0.5	34.5	51.1	
3,3 Dichlorobenzene	252	0.7	53.2	94.5	22
Bis(2-Ethyl-Hexyl) Phthalate	418	0.9	98.6	79	23
Di-n-Octyl Phthalate	386	1.5	62.3	88	15
Benzo(a)Pyrene	252	0.3	42.8	87	
Benzo(k)Fluoranthene	252	0.4	15.1	89	
Benzo(b)Fluoranthene	252	0.6	67.6	43	
Dibenzo(a,h)Anthracene	278	4.0	91.6	39	
Benzo(ghi)Perylene	276	1.5	45.5	44	1.5
Indeno(1,2,3-CD)Pyrene	276	1.3	56.4	43	
9H Fluorene	166	0.4	36.9	69	55
4-Chlorophenylphenylether	204	1.0	61.7	79	76
N-Nitroso-Diphenylamine	198	0.4	39.3	91	
1,2-Diphenyl Hydrazine	184	0.6	28	68	

TABLE 3-4. DETECTION LIMIT AND PERCENT RECOVERY OF PESTICIDES

PESTICIDE COMPOUNDS	DERIV MWT	MDL (µg/L)	% RECOV #1	% RECOV #2
Alpha BHC	290.8	0.7	81	91
Gamma BHC	290.8	1.7	>100	76
Beta BHC	290.8	0.5	73	65
Delta BHC	290.8	1.5	84	56
Heptachlor	373.3	1.3	91	43
Aldrin	364.9	1.0	86	79
Heptachlor Epoxide	389	0.6	84	57
Oxychlordane	420		92	85
Alpha Endosulfan	406.9	2.2	66	62
4,4'-DDE	318	0.8	96	70
Dieldrin	378	0.5	>100	68
Endrin	380.9	1.1	89	72
Beta Endosulfan	406.9	3.0	39	84
4,4'-DDD	316	0.6	>100	88
Endrin Aldehyde			48	56
Endosulfan Sulfate	422.9		82	77
4,4'-DDT	352	0.5	98	78
Methoxychlor	344	0.5	35	40
Mirex	540	2.5	37	32

TABLE 3-5. DETECTION LIMIT AND PERCENT RECOVERY OF PCBs

POLYCHLORINATED BIPHENYLS	MDL (µg/L)	PERCENT RECOVERY
STD #1 - 1016	5.2	87
1232	5.3	88
1248	20	92
1260	25	69
STD #2 - 1242	4.5	86
1221	5.1	86
1254	23	84
Chlordane	1.0	56
Toxaphene	50	67
D10 Phen		

APPENDIX 4

HAZPRED LISTING AND SAMPLE HAZPRED OUTPUT FOR THE YORK AND NORTH YORK CATCHMENTS

LISTING OF THE

HAZPRED PROGRAM

```
1       '
2       ' PROGRAM "HAZPRED6.BAS"     by  DAVID HEIT
3       '           (21/3/84)
4       '
5       ' Used to determine contaminant loading for a given municipal area
6       ' watershed. Taking into account residential, industrial commercial
7       ' and background tapwater contaminant concentrations.
8       '
9       ' Program contains modifications to allow industrial cooling water,
10      ' which acts as a dilutant factor to the industrial contribution.
11      ' Additionally, for the industrial component, the category of "OTHER"
12      ' SIC  group's contribution is calculated using the A.D. Little values.
13      '
14      ' Major Variables:
15      ' ----------------
16      ' WATER(15)          - Array containing the industrial water flows as
17      '                      broken by SIC group. (L/day)
18      ' CONTAM$(130)       - Array containing all the contaminant names. Read
19      '                      from data file "HCONTIND.DAT"
20      ' CONTCONC(16,130)   - Array containing the predicted levels of a cont..
21      '                      For each SIC group entered the array will have
22      '                      industrial concentration values. (ug/l)
27      ' INDCOMP(130)       - This array holds the new values for an industrial
28      '                      concentration component, to be used in the model.
29      '  MODEL(129)        - Array which holds the level prediction. (ug/l)
38      '   TOTWATER         - Total industrial wastewater flow (l/day)
39      '   COOL             - Industrial cooling water flow (l/day)
40      '   RWU              - Per capita residential wastewater flow.
                               (l/capita/day)
41      '   POP              - Residential population of the area.
42      '   CWU              - Commercial wastewater flow. (l/day)
43      '   QA               - Dry weather infiltration (l/day)
44      '   QT               - Total wastewater flow. (l/day)
49      '
50    KEY OFF:CLS:SCREEN 0,0,0:COLOR 2,0
55    DIM WATER(15),CONTNAM$(130),INDCOMP(130),MODEL(129),DIFF(129),RES(129),
      COMM(129),IND(129),CONTCONC(16,130)
60    SICC=0:B$=STRING$(9,32):C$=" ":D$="<"
65     GOSUB 120                          'Goto explanation page.
70     GOSUB 255                          'Enter in data except industrial
75     IF CHL=1 THEN GOTO 85
80     GOSUB 345                          'Enter in the industrial component
85     GOSUB 695                          'Calculate the ind. component
90     GOSUB 845                          'Printout the ind. component
95     GOSUB 1175                         'Determine the overall prediction
100    GOSUB 1675                         'Determine the yearly loading
105    GOSUB 1335                         'Printout the overall prediction
110    END
115     '-----------------------------------------------------------------------
120 COLOR 15,0:LOCATE 2,28:PRINT "PROGRAM  HAZPRED.BAS":LOCATE 4,37:COLOR 2,0
125 PRINT "BY":LOCATE 6,33:PRINT "DAVID HEIT"
130 LOCATE 8,18 :PRINT "COPYRIGHT (C) 1984 CANVIRO CONSULTANTS LTD.":PRINT
135 PRINT "          The purpose of this program is to provide you with typical"
140 PRINT "          hazourdous contaminant loading values for a given watershed.
"
145 PRINT:LOCATE 13,15:PRINT "In order to use this program you need to know:"
150 PRINT:PRINT "                 1) The residential population of the area."
155 PRINT "                2) The per capita residential wastewater generation."
```

```
160 PRINT "                  3) The total commercial wastewater flow."
165 PRINT "                  4) The industrial wastewater flow as categorized by:"

170 PRINT "                      a) Total industrial wastewater flow. (LEVEL 1)"
175 PRINT "                      b) Industrial wastewater flow as divided by
180 PRINT "                         SIC group category. (LEVEL 2)"
185  'GOSUB 2000                                'Load in the SIC conc. value data
190 LOCATE 23,25:COLOR 0,7:PRINT " PRESS ANY KEY TO CONTINUE "
195 A$=INKEY$:IF A$="" THEN GOTO 195
200 COLOR 2,0:CLS:LOCATE 5,8
205 PRINT "Please indicate which level you wish to use to make your prediction?"

210 LOCATE 7,10:PRINT " LEVEL 1  - prediction with the industrial component indi
cated"
215 LOCATE 8,22:PRINT "as a single total value."
220 LOCATE 10,10:PRINT " LEVEL 2  - prediction with the industrial component fur
ther"
225 LOCATE 11,22:PRINT "divided into :"
230 LOCATE 12,37:PRINT "1) Coolant water.":LOCATE 13,37:PRINT "2) SIC category f
lows."
235 LOCATE 17,22:INPUT "Choice ? (1 or 2) ",CHL$:CHL=VAL(CHL$):CHL=INT(CHL)
240 IF (CHL<1) OR (CHL>2) THEN BEEP:LOCATE 17,39:PRINT STRING$(40,32):GOTO 235
245 RETURN
250    '__________________________________________________________________
255  CLS:LOCATE 2,5
260 INPUT "What is the name of the area to be modelled ";CITY$:PRINT
265 INPUT "    What is the residential population ";POP:PRINT
270 INPUT "    What is the per capita residential wastewater flow (L/capita/day)
 ";RWU:PRINT
275 INPUT "    What is the total commercial wastewater flow (L/day) ";CWU:PRINT
280 INPUT "    What is the dry weather infiltration  (L/day) ";QA:PRINT
285 IF CHL=1 THEN INPUT "    What is the industrial wastewater flow (L/day) ";IW
U ELSE INPUT "    What is the industrial cooling water flow (L/day) ";COOL
290 PRINT
295 PRINT "      Area                               : "+CITY$
300 PRINT "      Population                         : "POP
305 PRINT "      liters/capita/day                  : "RWU
310 PRINT "      Commercial Wastewater Flow (l/day) : "CWU
315 PRINT "      Dry Weather Infiltraion (l/day)    : "QA
320 IF CHL=1 THEN PRINT "      Industrial Wastewater Flow (l/day) : "IWU ELSE PR
INT "      Industrial Coolant factor  (l/day) : "COOL
325 PRINT:INPUT "      Is this information correct (y/n) ";ANS$
330 ANS$=MID$(ANS$,1,1):IF ANS$="y" OR ANS$="Y" THEN RETURN
335 GOTO 255
340    '__________________________________________________________________
345 GOSUB 500
350    IF P=0 THEN CLS:TOTWATER=COOL:GOSUB 600:P=2
355 LOCATE 7,3:PRINT "Enter 0 for SIC group and wastewater output to terminate e
ntering data."
360 LOCATE 3,4:INPUT "Please state the industrial SIC group ";SIC$
365 SIC=VAL(SIC$)
370 IF SIC<0 OR SIC>9999 THEN LOCATE 3,42:PRINT STRING$(30,32):BEEP:GOTO 360
375 LOCATE 4,4:PRINT "Please state their wastewater output "+U$;
380 INPUT " ";IWATER$
385 IWATER=VAL(IWATER$)
390 IF IWATER>1000000000# THEN LOCATE 4,54:PRINT STRING$(25,32):BEEP:GOTO 375
395 ON NUM GOSUB 590,580,570,570
400 IF SIC=>2200 AND SIC<=2299 THEN WATER(8)=WATER(8)+IWATER:LOCATE 12,4:PRINT B
$:LOCATE 12,4:PRINT WATER(8):GOTO 475
405 IF SIC=>2821 AND SIC<=2824 THEN WATER(1)=WATER(1)+IWATER:LOCATE 12,17:PRINT
```

```
B$:LOCATE 12,17:PRINT WATER(1):GOTO 475
410 IF SIC=2834 THEN WATER(7)=WATER(7)+IWATER:LOCATE 12,33:PRINT B$:LOCATE 12,33
:PRINT WATER(7):GOTO 475
415 IF SIC=2841 THEN WATER(2)=WATER(2)+IWATER:LOCATE 12,50:PRINT B$:LOCATE 12,50
:PRINT WATER(2):GOTO 475
420 IF SIC=2844 THEN WATER(6)=WATER(6)+IWATER:LOCATE 12,65:PRINT B$:LOCATE 12,65
:PRINT WATER(6):GOTO 475
425 IF SIC=2851 THEN WATER(5)=WATER(5)+IWATER:LOCATE 15,4:PRINT B$:LOCATE 15,4:P
RINT WATER(5):GOTO 475
430 IF SIC=2893 THEN WATER(4)=WATER(4)+IWATER:LOCATE 15,17:PRINT B$:LOCATE 15,17
:PRINT WATER(4):GOTO 475
435 IF SIC=>3011 AND SIC<=3079 THEN WATER(3)=WATER(3)+IWATER:LOCATE 15,33:PRINT
B$:LOCATE 15,33:PRINT WATER(3):GOTO 475
440 IF SIC=3111 THEN WATER(12)=WATER(12)+IWATER:LOCATE 15,50:PRINT B$:LOCATE 15,
50:PRINT WATER(12):GOTO 475
445 IF SIC=3431 THEN WATER(9)=WATER(9)+IWATER:LOCATE 18,17:PRINT B$:LOCATE 18,17
:PRINT WATER(9):GOTO 475
450 IF SIC=3312 THEN WATER(10)=WATER(10)+IWATER:LOCATE 15,65:PRINT B$:LOCATE 15,
65:PRINT WATER(10):GOTO 475
455 IF SIC=>3321 AND SIC<=3325 THEN WATER(11)=WATER(11)+IWATER:LOCATE 18,4:PRINT
 B$:LOCATE 18,4:PRINT WATER(11):GOTO 475
460 IF SIC=3471 THEN WATER(14)=WATER(14)+IWATER:LOCATE 18,33:PRINT B$:LOCATE 18,
33:PRINT WATER(14):GOTO 475
465 IF SIC=3479 THEN WATER(13)=WATER(13)+IWATER:LOCATE 18,50:PRINT B$:LOCATE 18,
50:PRINT WATER(13):GOTO 475
470 WATER(15)=WATER(15)+IWATER:OTHERSIC(SICC)=SIC:SICC=SICC+1:LOCATE 18,65:PRINT
 B$:LOCATE 18,65:PRINT WATER(15)
475 TOTWATER=TOTWATER+IWATER:LOCATE 20,39:PRINT B$+B$:LOCATE 20,39:PRINT TOTWATE
R "(l/day)"
480 IF SIC=0 AND IWATER=0 THEN RETURN
485 LOCATE 3,4:PRINT STRING$(75,32):LOCATE 4,4:PRINT STRING$(75,32)
490 GOTO 360
495    '____________________________________________________________________________
500 CLS:LOCATE 8,10:PRINT "Please enter the format of the data to be analyzed:"
505 PRINT "             1) Liters per day"
510 PRINT "             2) Liters per year"
515 PRINT "             3) Imp. gallons per day"
520 PRINT "             4) Imp. gallons per year"
525 LOCATE 14,19:INPUT "choice (1-4) ";NUM$
530 NUM=VAL(NUM$)
535 IF NUM<1 OR NUM>4 THEN BEEP:LOCATE 14,33:PRINT STRING$(40,32):GOTO 525
540 U$="(Imp. gal/yr)"
545 IF NUM=1 THEN U$="(liters/day) "
550 IF NUM=2 THEN U$="(liters/year)"
555 IF NUM=3 THEN U$="(Imp.gal/day)"
560 RETURN
565    '____________________________________________________________________________
570 IWATER=IWATER*4.546
575 IF NUM=3 THEN GOTO 585
580 IWATER=IWATER/365                             'Convert whatever input units to (l/day)
585 IWATER=INT(IWATER)
590 RETURN
595    '____________________________________________________________________________
600 LOCATE 10,1
605 PRINT "INNNNNNNNNNNNNNNNNNNNNNNNNSIC GROUP WASTEWATER FLOWSNNNNNNNNNNNNNNNNNN
NNNNNNNNN;"
610 PRINT ":   2200-99      2821-24         2834             2841           2844
         :"
615 PRINT ":" TAB(5) WATER(8) TAB(17) WATER(1) TAB(33) WATER(7) TAB(50) WATER(2)
 TAB(65) WATER(6) TAB(79) ":"
```

```
620 PRINT ":" TAB(79) ":"
625 PRINT ":  2851        2993             3011-79         3111            3312
       :"
630 PRINT ":" TAB(5) WATER(5) TAB(17) WATER(4) TAB(33) WATER(3) TAB(50) WATER(12
) TAB(65) WATER(10) TAB(79) ":"
635 PRINT ":" TAB(79) ":"
640 PRINT ":  3321-3325   3431             3471            3479            OTHER
       :"
645 PRINT ":" TAB(5) WATER(11) TAB(17) WATER(9) TAB(33) WATER(14) TAB(50) WATER(
13) TAB(65) WATER(15) TAB(79) ":"
650 PRINT ":" TAB(79) ":"
655 PRINT ":   Total industrial wastewater flow:" TOTWATER " (1/day)"TAB(79)":"
660 PRINT "#####################################################################
#########<"
665 PRINT:PRINT " Industrial Coolant Water Flow (1/day)" COOL
670 RETURN
675    '--------------------------------------------------------------------
680    '
685    ' Calculate a new industrial conmponent concentration.
690    '
695 CLS:LOCATE 10,20:PRINT "Calculating Industrial Component"
700 GOSUB 1810
705 IF CHL=1 THEN GOTO 750
710 FOR SICN=1 TO 15
715     IF WATER(SICN)=0 THEN GOTO 740
720     FOR CNT=1 TO 129
725         IF CONTCONC(SICN,CNT)<=0 THEN GOTO 735
730         INDCOMP(CNT)=INDCOMP(CNT)+(CONTCONC(SICN,CNT)*WATER(SICN)/TOTWATER)
735     NEXT
740 NEXT
745 RETURN
750 FOR X=1 TO 38
755     READ NKEY,CNAME$,TW,TSD,RC,RCSD,CC,CCSD,IC
760     CONTCONC(16,X)=CONTCONC(16,NKEY)
765     INDCOMP(X)=IC:CONTNAM$(X)=CNAME$
770 NEXT
775 RESTORE
780 RETURN
785    '--------------------------------------------------------------------
790    '
795    ' Open files and devices as needed.
800    '
805 OPEN "HCONTIND.DAT" FOR INPUT AS #1
810 RETURN
815 OPEN "SCRN:" FOR OUTPUT AS #1
820 OPEN "LPT1:" FOR OUTPUT AS #2
825 LPRINT CHR$(15)
830 WIDTH #2,120
835 RETURN
840    '--------------------------------------------------------------------
845 CLS:P=1:IF CHL=1 THEN TOTWATER=IWU
850 GOSUB 815
855 QT=RWU*POP+CWU+TOTWATER+QA        'Total flow
860 PRINT #P,""
865 PRINT #P,"          OVERALL MODEL OF WASTEWATER FLOW"  TAB(65) DATE$
870 PRINT #P,"          --------------------------------"
875 PRINT #P,"Area                                      : "+CITY$
880 PRINT #P,"Total Wastewater Flow             (1/day) : "QT
885 PRINT #P,"Residential Wastewater Flow       (1/day) : "(RWU*POP)
890 PRINT #P,"Commercial Wastewater Flow        (1/day) : "CWU
```

```
895 PRINT #P,"Industrial Wastewater Flow       (l/day) : "TOTWATER
900 PRINT #P,"Dry Weather Infiltration Factor  (l/day) : "QA
905 IF CHL=1 THEN PRINT #P," ":GOTO 1055
910 PRINT #P,"Industrial Coolant Flow          (l/day) : "COOL
915 PRINT #P,""
920 IF P<>1 THEN GOTO 930 ELSE PRINT #P,"Press any key to continue."
925 A$=INKEY$:IF A$="" THEN GOTO 925
930 PRINT #P," ":C=1
935 PRINT #P,"           INDUSTRIAL COMPONENT"
940 PRINT #P,"           ---------------------"
945 PRINT #P,"Area   : "+CITY$
950 PRINT #P,""
955 PRINT #P,"Total Industrial Wastewater Flow (l/day) :" TOTWATER
960 PRINT #P,"Industrial Coolant Water Flow    (l/day) :" COOL
965 PRINT #P,""
970 PRINT #P," Breakdown by SIC  (l/day) "
975 PRINT #P,"----------------------------"
980 PRINT #P,"2200-2299 : " WATER(8)
985 PRINT #P,"2821-2824 : " WATER(1)
990 PRINT #P,"2834      : " WATER(7)
995 PRINT #P,"2841      : " WATER(2)
1000 PRINT #P,"2844      : " WATER(6)
1005 PRINT #P,"2851      : " WATER(5)
1010 PRINT #P,"2893      : " WATER(4)
1015 PRINT #P,"3011-3079 : " WATER(3)
1020 PRINT #P,"3111      : " WATER(12)
1025 PRINT #P,"3312      : " WATER(10)
1030 PRINT #P,"3321-3325 : " WATER(11)
1035 PRINT #P,"3431      : " WATER(9)
1040 PRINT #P,"3471      : " WATER(14)
1045 PRINT #P,"3479      : " WATER(13)
1050 PRINT #P,"Other SIC : " WATER(15):PRINT #P,""
1055 IF P<>1 THEN GOTO 1065 ELSE PRINT #P,"Press any key to continue."
1060 A$=INKEY$:IF A$="" THEN GOTO 1060
1065 PRINT #P,CHR$(12)
1070 PRINT #P,"" :CTR=0
1075 PRINT #P,"       PREDICTED INDUSTRIAL CONCENTRATIONS"
1080 PRINT #P,"       -------------------------------------":PRINT #P," "
1085 PRINT #P,"CONTAMINANT" TAB(35) "CONCENTRATION (ug/l)"
1090 PRINT #P,"-----------" TAB(35) "--------------------"
1095 FOR X=1 TO 129
1100      MDL$=C$
1105      IF INDCOMP(X)<(.1*CONTCONC(16,X)) THEN INDCOMP(X)=0
1110     IF INDCOMP(X)=0 THEN GOTO 1145
1115     IF INDCOMP(X)<CONTCONC(16,X) THEN MDL$=D$:TINDCOMP=CONTCONC(16,X) ELSE
TINDCOMP=INDCOMP(X)
1120     PRINT #P,CONTNAM$(X) TAB(34) MDL$ TAB(35);
1125     PRINT #P,USING"#######.##";TINDCOMP
1130     CTR=CTR+1
1135     GOSUB 1860
1140     IF CTR=54 THEN PRINT #P,CHR$(12):CTR=0
1145 NEXT
1150 IF P=2 THEN P=1:GOTO 1165
1155 INPUT "Would you also like hardcopy? (y/n) ",ANS$
1160 ANS$=MID$(ANS$,1,1):IF ANS$="y" OR ANS$="Y" THEN P=2:GOTO 865
1165 RETURN
1170    '______________________________________________________________________
1175 CLS
1180 LOCATE 10,20:PRINT "Now calculating an overall model"
1185 NKEY=0
```

```
1190 IF CHL=1 THEN GOTO 1280
1195 FOR C=1 TO 129
1200      IF C>NKEY AND C<129 THEN GOSUB 1270
1205      IF (C<NKEY OR C>128) AND (INDCOMP(C)=0) THEN GOTO 1260
1210      IF C=NKEY THEN GOTO 1230
1215      MODEL(C)=(TOTWATER*INDCOMP(C))/QT
1220      IND(C)=255*TOTWATER*INDCOMP(C)*1E-09
1225      GOTO 1260
1230       RES(C)=365*(POP*RWU)*RC*1E-09
1235       COMM(C)=300*(CWU*CC)*1E-09
1240       IND(C)=255*TOTWATER*INDCOMP(C)*1E-09
1245       OCOMP=(POP*RWU*RC)+(CWU*CC)
1250       MODEL(C)=(DCOMP+TOTWATER*INDCOMP(C))/QT
1255       IF MODEL(C)<(.1*CONTCONC(16,C)) THEN MODEL(C)=0
1260 NEXT
1265 RETURN
1270 READ NKEY,CNAME$,TW,TSD,RC,RCSD,CC,CCSD,IC
1275 RETURN
1280 RESTORE
1285 FOR X=1 TO 38
1290      GOSUB 1270
1295      MODEL(X)=((POP*RWU*RC)+(CWU*CC)+(IC*INU))/QT
1300      RES(X)=365*(POP*RWU)*RC*1E-09
1305      COMM(X)=300*(CWU*CC)*1E-09
1310      IND(X)=255*TOTWATER*IC*1E-09
1315      IF MODEL(X)<(.1*CONTCONC(16,X)) THEN MODEL(X)=0
1320 NEXT
1325 RETURN
1330    '-----------------------------------------------------------------------
1335 CLS
1340 PRINT #P,CHR$(12):CTR=1
1345 PRINT #P,"   Overall Contaminant Concentration Predictions"
1350 PRINT #P,"  ------------------------------------------------"
1355 PRINT #P,"Contaminant" TAB(42) "Concentration (ug/l)"
1360 PRINT #P,"-----------" TAB(42) "--------------------"
1365 FOR C=1 TO 129
1370      MDL$=C$
1375      IF MODEL(C)=0 THEN GOTO 1405
1380      IF MODEL(C)<CONTCONC(16,C) THEN TMODEL=CONTCONC(16,C):MDL$=D$ ELSE TMOD
EL=MODEL(C)
1385      PRINT #P,CONTNAM$(C) TAB(40) MDL$ TAB(41);
1390      PRINT #P,USING "#######.##   ";TMODEL
1395      GOSUB 1860
1400      CTR=CTR+1:IF CTR=54 THEN PRINT #P,CHR$(12):CTR=1
1405 NEXT
1410 IF P=2 THEN P=1:GOTO 1425
1415 INPUT "Would you also like hardcopy? (y/n) ",ANS$
1420 ANS$=MID$(ANS$,1,1):IF ANS$="y" OR ANS$="Y" THEN P=2:GOTO 1340
1425 RETURN
1430    '-----------------------------------------------------------------------
1435    '-----------------------------------------------------------------------
1440    '-----------------------------------------------------------------------
1445    '
1450    ' AD LITTLE data used for MODEL 1 and by the other SIC category in
1455    ' MODEL 2.
1460    ' Data order : Parameter key,Contaminant name,Tap water conc.,Tap water
1465    '              std.dev.,Residential conc.,Res. std.dev.,Commercial conc.,
1470    '              Com. std.dev.,Industrial Concentration
1475    '
1480 DATA 4,BENZENE,.0,.0,.2,.4,2.7,2.1,1.2
```

```
1485 DATA 6,"CARBON TETRACHLORIDE",.0,.0,.0,.0,.1,.2,28.4
1490 DATA 7,CHLOROBENZENE,.0,.0,.1,.1,.0,.1,.9
1495 DATA 10,"1,2-DICHLOROETHANE",.0,.0,.1,.1,.1,.2,.6
1500 DATA 11,"1,1,1-TRICHLOROETHANE",.6,1.3,2.3,2.8,2.9,1.8,85.1
1505 DATA 13,"1,1-DICHLOROETHANE",.0,.0,.0,.0,.1,.1,1.6
1510 DATA 23,CHLOROFORM,27.1,8.6,3.0,.9,6.7,2.0,12.0
1515 DATA 25,"DICHLOROBENZENES",.0,.0,2.8,5.5,7.5,11.3,376.5
1520 DATA 29,"1,1-DICHLOROETHYLENE",.0,.0,.0,.0,.3,.5,11.6
1525 DATA 30,"1,2-T-DICHLOROETHYLENE",.0,.0,.0,.0,1.5,2.0,11.7
1530 DATA 34,"2,4-DIMETHYL PHENOL",.0,.0,.7,.8,.0,.0,74.0
1535 DATA 38,"ETHYL BENZENE",.1,.1,.4,.5,3.0,3.1,100.4
1540 DATA 47,BROMOFORM,.8,.9,.0,.0,.0,.0,.0
1545 DATA 48,BROMODICHLOROMETHANE,8.8,6.9,.0,.1,1.0,1.2,1.6
1550 DATA 51,DIBROMOCHLOROMETHANE,5.9,7.1,.0,.0,.7,.9,1.2
1555 DATA 55,NAPHTHALENE,.0,.0,2.1,2.9,2.6,3.2,50.7
1560 DATA 64,PENTACHLOROPHENOL,.0,.0,1.2,2.4,5.8,11.5,10.1
1565 DATA 65,PHENOL,.0,.0,5.8,5.6,4.5,.8,135.8
1570 DATA 66,"BIS(2-ETHYLHEXYL)PHTHALATE",4.1,8.3,6.8,8.1,7.7,7.4,43.0
1575 DATA 67,"BUTYL BENZYL PHTHALATE",.0,.0,6.8,7.5,10.6,3.3,168.2
1580 DATA 68,"DI-N-BUTYL PHTHALATE",4.5,6.7,9.0,6.5,11.7,11.2,67.1
1585 DATA 70,"DIETHYL PHTHALATE",.8,1.6,9.8,11.6,5.7,7.0,.0
1590 DATA 85,"TETRACHLOROETHYLENE",.8,.9,6.3,7.6,21.4,13.3,69.9
1595 DATA 86,TOLUENE,.3,.5,2.6,2.7,11.0,6.8,52.3
1600 DATA 87,TRICHLOROETHYLENE,.0,.0,.4,.5,12.8,25.6,25.4
1605 DATA 114,ANTIMONY,3.0,6.0,2.7,3.8,.3,.4,1.7
1610 DATA 115,ARSENIC,1.6,3.1,4.8,8.7,2.6,4.2,3.2
1615 DATA 118,CADMIUM,.5,1.0,1.8,1.6,.6,.9,20.7
1620 DATA 119,CHROMIUM,2.5,5.0,16.3,6.1,56.8,84.0,713.2
1625 DATA 120,COPPER,28.4,21.0,72.1,32.4,54.5,21.2,124.8
1630 DATA 121,"TOTAL CYANIDES",.0,.0,1.1,1.8,.2,.4,90.7
1635 DATA 122,LEAD,10.4,13.5,97.3,135.8,49.8,32.8,323.7
1640 DATA 123,MERCURY,.0,.0,.4,.5,.4,.4,1.9
1645 DATA 124,NICKEL,4.3,6.1,4.2,3.7,12.4,3.9,108.7
1650 DATA 125,SELENIUM,2.9,3.8,3.8,4.7,3.3,4.2,.9
1655 DATA 126,SILVER,.3,.5,2.2,2.5,2.9,3.0,150.4
1660 DATA 127,THALLIUM,.0,.0,.0,.0,.1,.2,.1
1665 DATA 128,ZINC,66.9,95.6,214.0,175.7,138.1,30.3,860.0
1670   '------------------------------------------------------------------
1675   '------------------------------------------------------------------
1680    '
1685    ' Calculate and output the yearly loading of contaminants for the 3
1690    ' areas. (RES.,COMM.,&IND.)
1695 P=1
1700 CTR=0:PRINT #P,CHR$(12)
1705 PRINT #P,TAB(28) "PREDICTED YEARLY LOADING"
1710 PRINT #F,TAB(28) "------------------------"
1715 PRINT #P,"Contaminant" TAB(39) "Res" TAB(50) "Com" TAB(61) "Ind" TAB(72) "T
otal"
1720 PRINT #P,TAB(37) "(kg/yr)" TAB(48) "(kg/yr)" TAB(59) "(kg/yr)" TAB(71) "(kg
/yr)"
1725 FOR X=1 TO 129
1730      IF MODEL(X)=0 THEN GOTO 1760
1735      TOTLOAD=RES(X)+COMM(X)+IND(X)
1740      PRINT #P,CONTNAM$(X) TAB(35);
1745      PRINT #P,USING "######.##  ";RES(X),COMM(X),IND(X),TOTLOAD
1750      GOSUB 1860
1755      CTR=CTR+1:IF CTR>55 THEN CTR=0:PRINT #P,CHR$(12)
1760 NEXT
1765 IF P=2 THEN P=1 : GOTO 1780
1770 INPUT "Would you also like hardcopy? (y/n) ",ANS$
```

```
1775 ANS$=MID$(ANS$,1,1):IF ANS$="y" OR ANS$="Y" THEN P=2:GOTO 1700
1780 RETURN
1785  '__________________________________________________________________
1790   '
1795   ' Load in the SIC contaminant concentrations which will be used to
1800   ' calculate new industrial components.
1805   '
1810 GOSUB 805
1815 FOR Y=1 TO 129
1820     INPUT #1,CONTNAM$(Y)
1825     FOR X=1 TO 16
1830        INPUT #1,CONTCONC(X,Y)
1835     NEXT
1840 NEXT
1845 CLOSE #1
1850 RETURN
1855  '__________________________________________________________________
1860  IF P=2 THEN RETURN
1865  IF (P=1) AND (CTR=19) THEN GOTO 1870 ELSE RETURN
1870 LOCATE 25,28:PRINT "Press Any Key to Continue."
1875 A$=INKEY$:IF A$="" THEN GOTO 1875
1880 CTR=0:CLS
1885 RETURN
```

YORK

LEVEL I

```
                OVERALL MODEL OF WASTEWATER FLOW                 03-27-1984
                --------------------------------
Area                                      : YORK
Total Wastewater Flow            (l/day) :  2496197
Residential Wastewater.Flow      (l/day) :  909540
Commercial Wastewater Flow       (l/day) :  48890
Industrial Wastewater Flow       (l/day) :  427737
Dry Weather Infiltration Factor  (l/day) :  1110030
```

PREDICTED INDUSTRIAL CONCENTRATIONS

CONTAMINANT	CONCENTRATION (ug/l)
BENZENE	1.20
CARBON TETRACHLORIDE	28.40
CHLOROBENZENE	< 1.00
1,2-DICHLOROETHANE	< 1.00
1,1,1-TRICHLOROETHANE	85.10
1,1-DICHLOROETHANE	1.60
CHLOROFORM	12.00
DICHLOROBENZENES	376.50
1,1-DICHLOROETHYLENE	11.60
1,2-T-DICHLOROETHYLENE	11.70
2,4-DIMETHYL PHENOL	74.00
ETHYL BENZENE	100.40
BROMODICHLOROMETHANE	1.60
DIBROMOCHLOROMETHANE	< 1.50
NAPHTHALENE	50.70
PENTACHLOROPHENOL	< 17.50
PHENOL	135.80
BIS(2-ETHYLHEXYL)PHTHALATE	43.00
BUTYL BENZYL PHTHALATE	168.20
DI-N-BUTYL PHTHALATE	67.10
TETRACHLOROETHYLENE	69.90
TOLUENE	52.30
TRICHLOROETHYLENE	25.40
ANTIMONY	< 2.00
ARSENIC	3.20
CADMIUM	20.70
CHROMIUM	713.20
COPPER	124.80
TOTAL CYANIDES	90.70
LEAD	323.70
MERCURY	1.90
NICKEL	108.70
SELENIUM	< 3.00
SILVER	150.40
THALLIUM	< 1.00
ZINC	860.00

Overall Contaminant Concentration Predictions

Contaminant	Concentration (ug/l)
BENZENE	< 1.00
CARBON TETRACHLORIDE	4.87
CHLOROBENZENE	< 1.00
1,2-DICHLOROETHANE	< 1.00
1,1,1-TRICHLOROETHANE	15.48
1,1-DICHLOROETHANE	< 1.50
CHLOROFORM	3.28
DICHLOROBENZENES	65.68
1,1-DICHLOROETHYLENE	< 3.00
1,2-T-DICHLOROETHYLENE	2.03
2,4-DIMETHYL PHENOL	12.94
ETHYL BENZENE	17.41
BROMODICHLOROMETHANE	< 1.00
DIBROMOCHLOROMETHANE	< 1.50
NAPHTHALENE	< 10.00
PENTACHLOROPHENOL	< 17.50
PHENOL	25.47
BIS(2-ETHYLHEXYL)PHTHALATE	< 10.00
BUTYL BENZYL PHTHALATE	31.51
DI-N-BUTYL PHTHALATE	15.01
DIETHYL PHTHALATE	< 10.00
TETRACHLOROETHYLENE	14.69
TOLUENE	10.12
TRICHLOROETHYLENE	4.75
ANTIMONY	< 2.00
ARSENIC	< 3.00
CADMIUM	4.21
CHROMIUM	129.26
COPPER	48.72
TOTAL CYANIDES	15.95
LEAD	91.90
MERCURY	< 1.50
NICKEL	20.40
SELENIUM	< 3.00
SILVER	26.63
ZINC	228.05

PREDICTED YEARLY LOADING

Contaminant	Res (kg/yr)	Com (kg/yr)	Ind (kg/yr)	Total (kg/yr)
BENZENE	0.07	0.04	0.13	0.24
CARBON TETRACHLORIDE	0.00	0.00	3.10	3.10
CHLOROBENZENE	0.03	0.00	0.10	0.13
1,2-DICHLOROETHANE	0.03	0.00	0.07	0.10
1,1,1-TRICHLOROETHANE	0.76	0.04	9.28	10.09
1,1-DICHLOROETHANE	0.00	0.00	0.17	0.18
CHLOROFORM	1.00	0.10	1.31	2.40
DICHLOROBENZENES	0.93	0.11	41.07	42.11
1,1-DICHLOROETHYLENE	0.00	0.00	1.27	1.27
1,2-T-DICHLOROETHYLENE	0.00	0.02	1.28	1.30
2,4-DIMETHYL PHENOL	0.23	0.00	8.07	8.30
ETHYL BENZENE	0.13	0.04	10.95	11.13
BROMODICHLOROMETHANE	0.00	0.01	0.17	0.19
DIBROMOCHLOROMETHANE	0.00	0.01	0.13	0.14
NAPHTHALENE	0.70	0.04	5.53	6.27
PENTACHLOROPHENOL	0.40	0.09	1.10	1.59
PHENOL	1.93	0.07	14.81	16.80
BIS(2-ETHYLHEXYL)PHTHALATE	2.26	0.11	4.69	7.06
BUTYL BENZYL PHTHALATE	2.26	0.16	18.35	20.76
DI-N-BUTYL PHTHALATE	2.99	0.17	7.32	10.48
DIETHYL PHTHALATE	3.25	0.08	0.00	3.34
TETRACHLOROETHYLENE	2.09	0.31	7.62	10.03
TOLUENE	0.86	0.16	5.70	6.73
TRICHLOROETHYLENE	0.13	0.19	2.77	3.09
ANTIMONY	0.90	0.00	0.19	1.09
ARSENIC	1.59	0.04	0.35	1.98
CADMIUM	0.60	0.01	2.26	2.86
CHROMIUM	5.41	0.83	77.79	84.04
COPPER	23.94	0.80	13.61	38.35
TOTAL CYANIDES	0.37	0.00	9.89	10.26
LEAD	32.30	0.73	35.31	68.34
MERCURY	0.13	0.01	0.21	0.35
NICKEL	1.39	0.18	11.86	13.43
SELENIUM	1.26	0.05	0.10	1.41
SILVER	0.73	0.04	16.40	17.18
ZINC	71.04	2.03	93.80	166.87

YORK

LEVEL II

```
                OVERALL MODEL OF WASTEWATER FLOW                   03-27-1984
                --------------------------------

Area                                      : YORK
Total Wastewater Flow            (l/day) :  2524860
Residential Wastewater Flow      (l/day) :  909540
Commercial Wastewater Flow       (l/day) :  48890
Industrial Wastewater Flow       (l/day) :  456400
Dry Weather Infiltration Factor  (l/day) :  1110030
Industrial Coolant Flow          (l/day) :  334300


                INDUSTRIAL COMPONENT
                --------------------

Area   : YORK

Total Industrial Wastewater Flow (l/day) : 456400
Industrial Coolant Water Flow    (l/day) : 334300

 Breakdown by SIC  (l/day)
---------------------------

2200-2299 :  0
2821-2824 :  0
2834      :  0
2841      :  0
2844      :  0
2851      :  10680
2893      :  0
3011-3079 :  14140
3111      :  0
3312      :  0
3321-3325 :  0
3431      :  0
3471      :  0
3479      :  0
Other SIC :  97280
```

PREDICTED INDUSTRIAL CONCENTRATIONS

CONTAMINANT	CONCENTRATION (ug/l)
ACRYLONITRILE	185.89
BENZENE	29.30
CARBON TETRACHLORIDE	11.86
CHLOROBENZENE	< 1.00
1,2-DICHLOROETHANE	2.36
1,1,1-TRICHLOROETHANE	20.06
1,1-DICHLOROETHANE	< 1.50
1,1,2-TRICHLOROETHANE	< 1.00
CHLOROETHANE	76.52
CHLOROFORM	5.98
DICHLOROBENZENES	80.25
1,1-DICHLOROETHYLENE	3.01
1,2-T-DICHLOROETHYLENE	2.82
1,2-DICHLOROPROPANE	< 1.00
2,4-DIMETHYL PHENOL	15.77
ETHYL BENZENE	49.56
DICHLOROMETHANE	19.08
BROMODICHLOROMETHANE	< 1.00
DIBROMOCHLOROMETHANE	< 1.50
NAPHTHALENE	12.07
NITROBENZENE	< 15.00
PENTACHLOROPHENOL	19.70
PHENOL	37.25
BIS(2-ETHYLHEXYL)PHTHALATE	21.27
BUTYL BENZYL PHTHALATE	35.85
DI-N-BUTYL PHTHALATE	20.39
TETRACHLOROETHYLENE	20.28
TOLUENE	72.03
TRICHLOROETHYLENE	6.63
ANTIMONY	< 2.00
ARSENIC	< 3.00
CADMIUM	9.53
CHROMIUM	165.37
COPPER	42.48
TOTAL CYANIDES	19.80
LEAD	99.80
MERCURY	26.21
NICKEL	32.70
SELENIUM	< 3.00
SILVER	32.17
THALLIUM	< 1.00
ZINC	547.43

Overall Contaminant Concentration Predictions

Contaminant	Concentration (ug/l)
ACRYLONITRILE	33.60
BENZENE	5.42
CARBON TETRACHLORIDE	2.15
1,2-DICHLOROETHANE	< 1.00
1,1,1-TRICHLOROETHANE	4.51
1,1,2-TRICHLOROETHANE	< 1.00
CHLOROETHANE	13.83
CHLOROFORM	2.29
DICHLOROBENZENES	< 20.00
1,1-DICHLOROETHYLENE	< 3.00
1,2-T-DICHLOROETHYLENE	< 1.00
1,2-DICHLOROPROPANE	< 1.00
2,4-DIMETHYL PHENOL	< 10.00
ETHYL BENZENE	9.16
DICHLOROMETHANE	3.45
BROMODICHLOROMETHANE	< 1.00
NAPHTHALENE	< 10.00
NITROBENZENE	< 15.00
PENTACHLOROPHENOL	< 17.50
PHENOL	< 10.00
BIS(2-ETHYLHEXYL)PHTHALATE	< 10.00
BUTYL BENZYL PHTHALATE	< 10.00
DI-N-BUTYL PHTHALATE	< 10.00
DIETHYL PHTHALATE	< 10.00
TETRACHLOROETHYLENE	6.35
TOLUENE	14.17
TRICHLOROETHYLENE	1.59
ANTIMONY	< 2.00
ARSENIC	< 3.00
CADMIUM	2.38
CHROMIUM	36.86
COPPER	34.71
TOTAL CYANIDES	< 15.00
LEAD	54.05
MERCURY	4.89
NICKEL	< 15.50
SELENIUM	< 3.00
SILVER	6.66
ZINC	178.72

PREDICTED YEARLY LOADING

Contaminant	Res (kg/yr)	Com (kg/yr)	Ind (kg/yr)	Total (kg/yr)
ACRYLONITRILE	0.00	0.00	21.63	21.63
BENZENE	0.07	0.04	3.41	3.52
CARBON TETRACHLORIDE	0.00	0.00	1.38	1.38
1,2-DICHLOROETHANE	0.03	0.00	0.27	0.31
1,1,1-TRICHLOROETHANE	0.76	0.04	2.33	3.14
1,1,2-TRICHLOROETHANE	0.00	0.00	0.01	0.01
CHLOROETHANE	0.00	0.00	8.91	8.91
CHLOROFORM	1.00	0.10	0.70	1.79
DICHLOROBENZENES	0.93	0.11	9.34	10.38
1,1-DICHLOROETHYLENE	0.00	0.00	0.35	0.35
1,2-T-DICHLOROETHYLENE	0.00	0.02	0.33	0.35
1,2-DICHLOROPROPANE	0.00	0.00	0.03	0.03
2,4-DIMETHYL PHENOL	0.23	0.00	1.84	2.07
ETHYL BENZENE	0.13	0.04	5.77	5.94
DICHLOROMETHANE	0.00	0.00	2.22	2.22
BROMODICHLOROMETHANE	0.00	0.01	0.11	0.13
NAPHTHALENE	0.70	0.04	1.40	2.14
NITROBENZENE	0.00	0.00	0.30	0.30
PENTACHLOROPHENOL	0.40	0.09	2.29	2.78
PHENOL	1.93	0.07	4.34	6.33
BIS(2-ETHYLHEXYL)PHTHALATE	2.26	0.11	2.48	4.85
BUTYL BENZYL PHTHALATE	2.26	0.16	4.17	6.59
DI-N-BUTYL PHTHALATE	2.99	0.17	2.37	5.53
DIETHYL PHTHALATE	3.25	0.08	0.00	3.34
TETRACHLOROETHYLENE	2.09	0.31	2.36	4.77
TOLUENE	0.86	0.16	8.38	9.41
TRICHLOROETHYLENE	0.13	0.19	0.77	1.09
ANTIMONY	0.90	0.00	0.11	1.01
ARSENIC	1.59	0.04	0.22	1.85
CADMIUM	0.60	0.01	1.11	1.72
CHROMIUM	5.41	0.83	19.25	25.49
COPPER	23.94	0.80	4.94	29.68
TOTAL CYANIDES	0.37	0.00	2.30	2.67
LEAD	32.30	0.73	11.61	44.65
MERCURY	0.13	0.01	3.05	3.19
NICKEL	1.39	0.18	3.81	5.38
SELENIUM	1.26	0.05	0.06	1.37
SILVER	0.73	0.04	3.74	4.52
ZINC	71.04	2.03	63.71	136.78

NORTH YORK

LEVEL I

```
                OVERALL MODEL OF WASTEWATER FLOW                      03-27-1984
                --------------------------------
Area                                     : NORTH YORK
Total Wastewater Flow           (l/day) :  9876501
Residential Wastewater Flow     (l/day) :  0
Commercial Wastewater Flow      (l/day) :  1757977
Industrial Wastewater Flow      (l/day) :  7314924
Dry Weather Infiltration Factor (l/day) :  803600
```

PREDICTED INDUSTRIAL CONCENTRATIONS

CONTAMINANT	CONCENTRATION (ug/l)
BENZENE	1.20
CARBON TETRACHLORIDE	28.40
CHLOROBENZENE	< 1.00
1,2-DICHLOROETHANE	< 1.00
1,1,1-TRICHLOROETHANE	85.10
1,1-DICHLOROETHANE	1.60
CHLOROFORM	12.00
DICHLOROBENZENES	376.50
1,1-DICHLOROETHYLENE	11.60
1,2-T-DICHLOROETHYLENE	11.70
2,4-DIMETHYL PHENOL	74.00
ETHYL BENZENE	100.40
BROMODICHLOROMETHANE	1.60
DIBROMOCHLOROMETHANE	< 1.50
NAPHTHALENE	50.70
PENTACHLOROPHENOL	< 17.50
PHENOL	135.80
BIS(2-ETHYLHEXYL)PHTHALATE	43.00
BUTYL BENZYL PHTHALATE	168.20
DI-N-BUTYL PHTHALATE	67.10
TETRACHLOROETHYLENE	69.90
TOLUENE	52.30
TRICHLOROETHYLENE	25.40
ANTIMONY	< 2.00
ARSENIC	3.20
CADMIUM	20.70
CHROMIUM	713.20
COPPER	124.80
TOTAL CYANIDES	90.70
LEAD	323.70
MERCURY	1.90
NICKEL	108.70
SELENIUM	< 3.00
SILVER	150.40
THALLIUM	< 1.00
ZINC	860.00

Overall Contaminant Concentration Predictions

Contaminant		Concentration (ug/l)
BENZENE		1.37
CARBON TETRACHLORIDE		21.05
CHLOROBENZENE	<	1.00
1,2-DICHLOROETHANE	<	1.00
1,1,1-TRICHLOROETHANE		63.54
1,1-DICHLOROETHANE	<	1.50
CHLOROFORM		10.00
DICHLOROBENZENES		280.19
1,1-DICHLOROETHYLENE		8.64
1,2-T-DICHLOROETHYLENE		8.93
2,4-DIMETHYL PHENOL		54.81
ETHYL BENZENE		74.89
BROMODICHLOROMETHANE		1.36
DIBROMOCHLOROMETHANE	<	1.50
NAPHTHALENE		38.01
PENTACHLOROPHENOL	<	17.50
PHENOL		101.38
BIS(2-ETHYLHEXYL)PHTHALATE		33.22
BUTYL BENZYL PHTHALATE		126.46
DI-N-BUTYL PHTHALATE		51.78
DIETHYL PHTHALATE	<	10.00
TETRACHLOROETHYLENE		55.58
TOLUENE		40.69
TRICHLOROETHYLENE		21.09
ANTIMONY	<	2.00
ARSENIC	<	3.00
CADMIUM		15.44
CHROMIUM		538.33
COPPER		102.13
TOTAL CYANIDES		67.21
LEAD		248.61
MERCURY	<	1.50
NICKEL		82.71
SELENIUM	<	3.00
SILVER		111.91
ZINC		661.53

PREDICTED YEARLY LOADING

Contaminant	Res (kg/yr)	Com (kg/yr)	Ind (kg/yr)	Total (kg/yr)
BENZENE	0.00	1.42	2.24	3.66
CARBON TETRACHLORIDE	0.00	0.05	52.97	53.03
CHLOROBENZENE	0.00	0.00	1.68	1.68
1,2-DICHLOROETHANE	0.00	0.05	1.12	1.17
1,1,1-TRICHLOROETHANE	0.00	1.53	158.74	160.27
1,1-DICHLOROETHANE	0.00	0.05	2.98	3.04
CHLOROFORM	0.00	3.53	22.38	25.92
DICHLOROBENZENES	0.00	3.96	702.29	706.24
1,1-DICHLOROETHYLENE	0.00	0.16	21.64	21.80
1,2-T-DICHLOROETHYLENE	0.00	0.79	21.82	22.62
2,4-DIMETHYL PHENOL	0.00	0.00	138.03	138.03
ETHYL BENZENE	0.00	1.58	187.28	188.86
BROMODICHLOROMETHANE	0.00	0.53	2.98	3.51
DIBROMOCHLOROMETHANE	0.00	0.37	2.24	2.61
NAPHTHALENE	0.00	1.37	94.57	95.94
PENTACHLOROPHENOL	0.00	3.06	18.84	21.90
PHENOL	0.00	2.37	253.31	255.68
BIS(2-ETHYLHEXYL)PHTHALATE	0.00	4.06	80.21	84.27
BUTYL BENZYL PHTHALATE	0.00	5.59	313.74	319.33
DI-N-BUTYL PHTHALATE	0.00	6.17	125.16	131.33
DIETHYL PHTHALATE	0.00	3.01	0.00	3.01
TETRACHLOROETHYLENE	0.00	11.29	130.38	141.67
TOLUENE	0.00	5.80	97.56	103.36
TRICHLOROETHYLENE	0.00	6.75	47.38	54.13
ANTIMONY	0.00	0.16	3.17	3.33
ARSENIC	0.00	1.37	5.97	7.34
CADMIUM	0.00	0.32	38.61	38.93
CHROMIUM	0.00	29.96	1330.34	1360.29
COPPER	0.00	28.74	232.79	261.53
TOTAL CYANIDES	0.00	0.11	169.18	169.29
LEAD	0.00	26.26	603.80	630.06
MERCURY	0.00	0.21	3.54	3.76
NICKEL	0.00	6.54	202.76	209.30
SELENIUM	0.00	1.74	1.68	3.42
SILVER	0.00	1.53	280.54	282.07
ZINC	0.00	72.83	1604.16	1677.00

NORTH YORK

LEVEL II

```
                    OVERALL MODEL OF WASTEWATER FLOW                     03-27-1984
                    --------------------------------
Area                                          : NORTH YORK
Total Wastewater Flow             (l/day) :  8248186
Residential Wastewater Flow       (l/day) :  0
Commercial Wastewater Flow        (l/day) :  1757977
Industrial Wastewater Flow        (l/day) :  5686609
Dry Weather Infiltration Factor   (l/day) :  803600
Industrial Coolant Flow           (l/day) :  0


              INDUSTRIAL COMPONENT
              --------------------

Area   : NORTH YORK

Total Industrial Wastewater Flow (l/day) : 5686609
Industrial Coolant Water Flow    (l/day) : 0

 Breakdown by SIC  (l/day)
-----------------------------

2200-2299 :  11503
2821-2824 :  0
2834      :  123753
2841      :  12780
2844      :  1490
2851      :  80487
2893      :  124024
3011-3079 :  240615
3111      :  0
3312      :  0
3321-3325 :  2730
3431      :  0
3471      :  400739
3479      :  29087
Other SIC :  4659401
```

PREDICTED INDUSTRIAL CONCENTRATIONS

CONTAMINANT	CONCENTRATION (ug/l)
ACRYLONITRILE	253.88
BENZENE	35.68
CARBON TETRACHLORIDE	33.05
CHLOROBENZENE	< 1.00
1,2-DICHLOROETHANE	5.20
1,1,1-TRICHLOROETHANE	83.14
1,1-DICHLOROETHANE	1.98
1,1,2-TRICHLOROETHANE	< 1.00
CHLOROETHANE	104.51
CHLOROFORM	15.84
DICHLOROBENZENES	308.71
1,1-DICHLOROETHYLENE	9.98
1,2-T-DICHLOROETHYLENE	9.90
1,2-DICHLOROPROPANE	< 1.00
2,4-DIMETHYL PHENOL	60.75
ETHYL BENZENE	219.60
DICHLOROMETHANE	82.28
BROMODICHLOROMETHANE	1.71
DIBROMOCHLOROMETHANE	1.92
ISOPHORONE	962.70
NAPHTHALENE	42.73
NITROBENZENE	< 15.00
PENTACHLOROPHENOL	38.58
PHENOL	121.07
BIS(2-ETHYLHEXYL)PHTHALATE	49.96
BUTYL BENZYL PHTHALATE	138.68
DI-N-BUTYL PHTHALATE	58.86
TETRACHLOROETHYLENE	64.30
TOLUENE	92.91
TRICHLOROETHYLENE	47.87
ANTIMONY	17.88
ARSENIC	4.33
CADMIUM	51.47
CHROMIUM	1553.99
COPPER	344.16
TOTAL CYANIDES	150.78
LEAD	1670.79
MERCURY	17.70
NICKEL	637.14
SELENIUM	< 3.00
SILVER	123.63
THALLIUM	< 1.00
ZINC	1465.59

Overall Contaminant Concentration Predictions

Contaminant	Concentration (ug/l)
ACRYLONITRILE	175.03
BENZENE	25.17
CARBON TETRACHLORIDE	22.81
CHLOROBENZENE	< 1.00
1,2-DICHLOROETHANE	3.60
1,1,1-TRICHLOROETHANE	57.94
1,1-DICHLOROETHANE	< 1.50
1,1,2-TRICHLOROETHANE	< 1.00
CHLOROETHANE	72.05
CHLOROFORM	12.35
DICHLOROBENZENES	214.44
1,1-DICHLOROETHYLENE	6.95
1,2-T-DICHLOROETHYLENE	7.15
1,2-DICHLOROPROPANE	< 1.00
2,4-DIMETHYL PHENOL	41.88
ETHYL BENZENE	152.04
DICHLOROMETHANE	56.73
BROMODICHLOROMETHANE	1.39
DIBROMOCHLOROMETHANE	< 1.50
ISOPHORONE	663.72
NAPHTHALENE	30.01
NITROBENZENE	< 15.00
PENTACHLOROPHENOL	27.83
PHENOL	84.43
BIS(2-ETHYLHEXYL)PHTHALATE	36.08
BUTYL BENZYL PHTHALATE	97.87
DI-N-BUTYL PHTHALATE	43.07
DIETHYL PHTHALATE	< 10.00
TETRACHLOROETHYLENE	48.89
TOLUENE	66.40
TRICHLOROETHYLENE	35.73
ANTIMONY	12.39
ARSENIC	3.54
CADMIUM	35.61
CHROMIUM	1083.48
COPPER	248.90
TOTAL CYANIDES	104.00
LEAD	1162.52
MERCURY	12.29
NICKEL	441.91
SELENIUM	< 3.00
SILVER	85.85
THALLIUM	< 1.00
ZINC	1039.87

PREDICTED YEARLY LOADING

Contaminant	Res (kg/yr)	Com' (kg/yr)	Ind (kg/yr)	Total (kg/yr)
ACRYLONITRILE	0.00	0.00	368.14	368.14
BENZENE	0.00	1.42	51.73	53.16
CARBON TETRACHLORIDE	0.00	0.05	47.93	47.98
CHLOROBENZENE	0.00	0.00	1.18	1.18
1,2-DICHLOROETHANE	0.00	0.05	7.54	7.59
1,1,1-TRICHLOROETHANE	0.00	1.53	120.56	122.09
1,1-DICHLOROETHANE	0.00	0.05	2.87	2.93
1,1,2-TRICHLOROETHANE	0.00	0.00	0.26	0.26
CHLOROETHANE	0.00	0.00	151.55	151.55
CHLOROFORM	0.00	3.53	22.97	26.50
DICHLOROBENZENES	0.00	3.96	447.66	451.62
1,1-DICHLOROETHYLENE	0.00	0.16	14.48	14.64
1,2-T-DICHLOROETHYLENE	0.00	0.79	14.36	15.15
1,2-DICHLOROPROPANE	0.00	0.00	1.24	1.24
2,4-DIMETHYL PHENOL	0.00	0.00	88.09	88.09
ETHYL BENZENE	0.00	1.58	318.44	320.02
DICHLOROMETHANE	0.00	0.00	119.31	119.31
BROMODICHLOROMETHANE	0.00	0.53	2.47	3.00
DIBROMOCHLOROMETHANE	0.00	0.37	2.79	3.15
ISOPHORONE	0.00	0.00	1396.00	1396.00
NAPHTHALENE	0.00	1.37	61.96	63.33
NITROBENZENE	0.00	0.00	2.31	2.31
PENTACHLOROPHENOL	0.00	3.06	55.94	59.00
PHENOL	0.00	2.37	175.56	177.94
BIS(2-ETHYLHEXYL)PHTHALATE	0.00	4.06	72.44	76.50
BUTYL BENZYL PHTHALATE	0.00	5.59	201.09	206.68
DI-N-BUTYL PHTHALATE	0.00	6.17	85.35	91.52
DIETHYL PHTHALATE	0.00	3.01	0.00	3.01
TETRACHLOROETHYLENE	0.00	11.29	93.24	104.53
TOLUENE	0.00	5.80	134.72	140.52
TRICHLOROETHYLENE	0.00	6.75	69.41	76.16
ANTIMONY	0.00	0.16	25.93	26.08
ARSENIC	0.00	1.37	6.29	7.66
CADMIUM	0.00	0.32	74.64	74.96
CHROMIUM	0.00	29.96	2253.42	2283.37
COPPER	0.00	28.74	499.07	527.81
TOTAL CYANIDES	0.00	0.11	218.65	218.75
LEAD	0.00	26.26	2422.79	2449.06
MERCURY	0.00	0.21	25.66	25.87
NICKEL	0.00	6.54	923.91	930.44
SELENIUM	0.00	1.74	1.79	3.53
SILVER	0.00	1.53	179.27	180.80
THALLIUM	0.00	0.05	0.99	1.04
ZINC	0.00	72.83	2125.23	2198.07

APPENDIX 5

SAMPLE INDUSTRIAL WATER-USE QUESTIONNAIRE

CANVIRO CONSULTANTS

INDUSTRIAL WATER-USE QUESTIONNAIRE
TORONTO AREA WATERSHED MANAGEMENT STUDY

NAME OF COMPANY: ____________________

ADDRESS: ____________________

TELEPHONE NO: ____________________

CONTACT PERSON: ____________________

POSITION: ____________________

TOTAL METERED
WATER USAGE: ____________________

1) PRINCIPAL PRODUCTS: ____________________

____

2) SIC DESIGNATION: ____________________

____

3) DISCHARGE TO SANITARY SEWER
OR COMBINED SEWER (Y/N): ____________________

____

COMPONENTS OF SANITARY DISCHARGE (process wastes, cooling water, sanitary):

____

ESTIMATED SANITARY COMPONENT QUANTITIES:

Process Waste + Sanitary: ____________________

Cooling Water: ____________________

4) DISCHARGE TO STORM SEWER (Y/N):__________

COMPONENTS OF STORM SEWER DISCHARGE (cooling water, other):

____

ESTIMATED STORM SEWER COMPONENT QUANTITIES:

Cooling: ____________________

Other: ____________________

5) IDENTIFY WET PROCESSES (e.g. plating lines):

____

6) IDENTIFY IN-PLANT PRETREATMENT(e.g. coagulation/sedimentation):

____

7) TYPE OF PROCESSING (batch/continuous): ______________________

8) NORMAL OPERATING PERIOD:

________ shifts/day

________ days/week

TD
735
.D48
1984

Development of a model
(HAZPRED) for predicting the
incidence of hazardous
contaminants in raw sewage -

77992